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Waterfowl and Shorebirds

Tule Greater White-Fronted Goose

Anser albifrons gambelli

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Introduction

The tule greater white-fronted goose or tule goose was selected to represent the geese and swans group which also includes Pacific greater white-fronted goose (*Anser albifrons frontalis*), Canada goose (*Branta canadensis*), Aleutian Canada goose (*B.c. leucopareia*), lesser snow goose (*Chen caerulescens*), and tundra swan (*Cygnus columbianus*).

Tule geese are primarily associated with managed wetlands and agriculture lands. The Suisun subregion is one of only a few important wintering areas in California. The geese/swan group is of economic and recreational importance as four of the six members of this group are hunted.

Although populations are relatively low in the San Francisco Bay Area for all species in this group, at least one representative is found in all subregions designated for the Goals process. Tule geese are primarily found in Suisun Marsh and North Bay (Napa Marsh); Pacific white-fronted geese, Suisun and North Bay; Canada geese, all subregions; Aleutian geese, Suisun and Central Bay; snow geese, all subregions; and tundra swans, Suisun and North Bay.

Courtesy USGS/NBS

Description

The tule goose is one of two subspecies of greater white-fronted geese that breed in Alaska and winter primarily in California (Swarth and Bryant 1917); the Pacific greater white-fronted goose is the other subspecies. Populations of the Pacific goose are far greater than the tule goose. The overall size of the tule goose is generally larger than the Pacific goose, although there may be overlap between the subspecies. The tule goose has a length to 34 inches (86 cm) and wing span to 65½ inches (167 cm) (Cogswell 1977). They are a medium-sized dark goose with the brown colors of the head and neck the same as the body and wings. Tule geese are a much darker brown than Pacifics. Adults have a white forehead and black blotched belly. In most tules, the forehead may show some orange coloration. Their feet are yellow and their bills are pink to orangish in color. Immatures do not have black blotched bellies.

Breeding Biology - Historically, nesting was known to occur at Redoubt Bay, in Cook Inlet, and suspected at Susitna Flats, Tuxedni Bay, Chinitna Bay, and Innoko National Wildlife Refuge (NWR), all in Alaska (Timm et al. 1982). Telemetry studies in 1995 showed breeding taking place on the Kahiltna and Yentna River Valleys northwest of Anchorage. Both areas were previously unreported as areas for tule geese. No radioed birds were found in the Redoubt or Trading Bay areas. The Redoubt Volcano eruption of 1989 may have made the area unfit for tule goose breeding. Few white-fronted geese have been counted in the area in the last five years. Nest initiation generally begins in early to mid-May or later depending on thaw on the breeding grounds. Incubation is 24-26 days. Clutch size averages 5-6 eggs (Timm et al. 1982, Zeiner et al. 1990). The subspecies is a monogamous, solitary nester, with both parents tending the young. Breeding may occur at two years of age, but three years is more common (Bellrose 1980).

Migration Ecology - Tule geese begin to leave Alaska by mid-August. By September 1 of 1980 and 1981 only a few hundred remained in Redoubt Bay or Susitna Flats (Timm et al. 1982). Generally, tule geese fly over the open ocean from Alaska to key staging areas

in southeastern Oregon, i.e., Summer Lake Wildlife Management Area and Malheur NWR. Up to 50% of the population may be present at these Oregon sites by early September and approximately 1,000-2,000 birds may remain until late October (Mensik 1991). Birds are also present in the Klamath Basin of Oregon and California during these times (Wege 1984). The remaining 50% of the population over-fly the fall staging areas arriving at Sacramento NWR in early September (Timm et al. 1982, Mensik 1991). Field observations at Grizzly Island Wildlife Area in the Suisun Marsh during the mid-1980s showed the first tule geese arriving during the September 9 to September 16 period (CDFG, unpubl. data). Historically, the primary spring migration staging area was the Klamath Basin where numbers peaked in late March. Results of radio telemetry studies in 1994-95 showed that few tule geese used Lower Klamath NWR while Summer Lake, Chewaucan Marsh, and the Warner Valley, all in Oregon, provided the principal spring staging areas (USDI 1995). Tule geese begin leaving central California in February (Mensik 1991). By mid-February of 1989 more than 1,400 tule geese remained at the Grizzly Island Wildlife Area (CDFG, unpubl. data).

Wintering Ecology - Primary wintering areas in California are the Sacramento Valley and Suisun Marsh. A small number of birds use the Napa Marsh. Use is mostly at Sacramento and Delevan NWRs and adjacent rice fields. Colusa NWR also receives some use. By October and November, an estimated 90% of the tule goose population occurs in these areas (Mensik 1991). Generally, there is a winter-long interchange of geese between the three most important areas, Sacramento NWR, Delevan NWR, and Grizzly Island Wildlife Area, although for the 1995 mark-recapture survey no tule geese were observed at Grizzly Island Wildlife Area during the September ground counts (Trost and Harb 1995). Other areas where tule geese have been observed in the past include the Butte Sink, Sutter NWR, San Joaquin Valley, and Sinaloa, Mexico (Wege 1984; Ely and Takekawa 1990; Kramer, pers. comm.; Timm et al. 1982; PFSC 1991).

Distribution and Abundance

North America - In North America, tule geese have been documented in the Central Flyway, although their status there is uncertain and there are no population estimates. A specimen of this subspecies of greater white-fronted geese was collected in Texas in 1852 by Hartlaub and subsequently described as one of the greater white-fronted geese (Swarth and Bryant 1917). The bird is primarily found in the Pacific Flyway where most of the studies to locate nesting, migration, and wintering areas have been done.

Pacific Coast - Nesting is known to occur at Redoubt Bay and Susitna Flats in the Cook Inlet, Alaska. Nesting also takes place northwest of Anchorage, Alaska in the Kahiltna and Yentna River Valleys. Ongoing telemetry studies are attempting to document additional breeding areas. Malheur NWR and Summer Lake Wildlife Management Area, along with Klamath Basin NWRs in Oregon and California, are the most important fall and spring migration stopover sites. Sacramento and Delevan NWRs and Grizzly Island Wildlife Area in the Suisun Marsh are the major wintering areas. Other areas important to winter birds are the Butte Sink, Colusa NWR, and the Napa Marsh near where the Napa River enters San Pablo Bay.

San Francisco Bay - Locally, the tule goose is only found in the Suisun and North Bay subregions. Suisun Marsh is the third most important wintering area in California. In the North Bay Region (Napa Marsh), a small population uses the marshes, sloughs, and adjacent agricultural lands (**Figure 6.1**).

Suisun - Suisun Marsh is the third most important wintering area in California. The peak population index of 1,500 was in December 1980 at Grizzly Island Wildlife Area in the Suisun Marsh. Other high indices were in December 1978 (1,000), December 1981 (1,200), February 1989 (1,229), and February 1990 (1,190) (Mensik 1991). The mid-winter waterfowl survey of January 1991 showed 1,527 tule geese. Waterfowl surveys during the period October 1992 through January 1997 showed the tule geese numbers to be generally less than 500 birds (CDFG, unpubl. data).

North Bay - The Napa Marshes of the North Bay region support a small wintering population of tule geese. Reports from duck hunters and hunting club owners are that the peak wintering population is less than 50 birds.

Central Bay - Not present.

South Bay - Not present.

Historical information

Since the late 1960s, the following information has been gathered for tule goose on an irregular basis: population size and distribution, including fall and winter counts of national wildlife refuges and state-managed wildlife areas, and periodic leg banding and color marking; production assessment, including age composition and family size counts on staging and wintering areas; and mortality assessment and harvest management, including monitoring harvest on selected public hunting areas and disease mortality on national wildlife refuges and state-managed wildlife areas.

Population Trends

Information has been gathered sporadically on tule geese in conjunction with other projects since the late 1960s. There has been more intensive study of the tule goose during the last 20 years. **Table 6.1** shows population

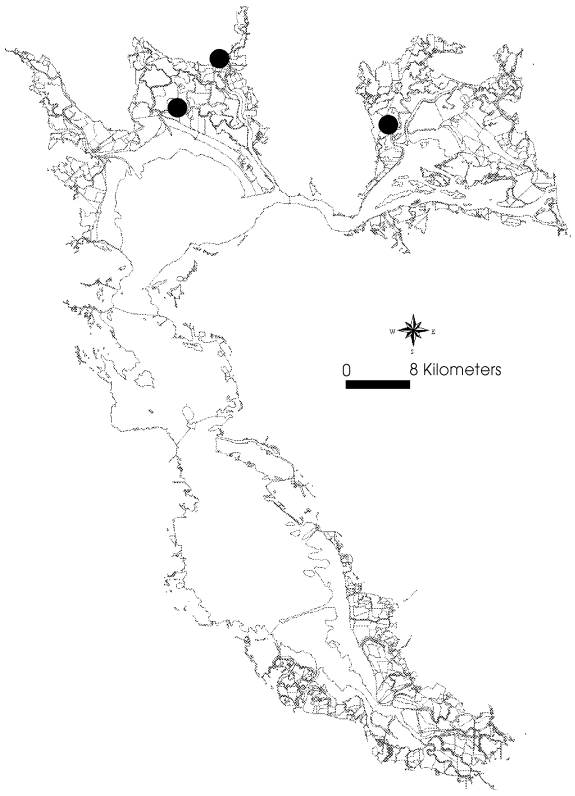

Figure 6.1 Distribution of Tule Greater White-Fronted Goose in San Francisco Bay

Open water data from the USGS Study of Waterfowl in Open Bays and Salt Ponds, 1988-1990 (USGS, unpubl.), John Takekawa (unpubl. data),

trend data for selected years between 1978-79 to 1989-90. The peak index of 8,615 was in September 1989. Observations of radioed and neck-collared tule geese in the fall and winter of 1995 (September 5 - December 31, 1995) documented approximately 6,000 birds in California and southern Oregon (Trost and Harb 1995).

Habitat Use and Behavior

Foraging - Foraging on the breeding grounds occurs on grasses, sedges, and aquatic plants in the intertidal mudflats, freshwater marshes, or poorly drained areas characteristic of the region. They are primarily grazers, but they will grub for roots and shoots (Zeiner et al. 1990). In the fall at Klamath Basin, they feed in ponds with alkali bulrush (*Scirpus robustus*) or harvested grain fields. Roosting occurs in open water ponds (Wege 1980). During early fall in the Sacramento Valley, they feed in harvested rice fields then shift to winter flooded uplands. Marsh units on Sacramento and Delevan NWRs with an abundance of alkali bulrush and with some open water are also used for feeding, which continues until departure in February (Wege 1980, Timm et al. 1982).

Roosting - Roosting and loafing generally occurs in open water ponds with emergents such as bulrush (*Scirpus* spp.) and cattails (*Typha* spp.). In the Suisun Marsh tule geese feed in ponds with alkali bulrush or in the barley/grass uplands of the sanctuary on Grizzly Island Wildlife Area. Roosting areas have shallowly flooded uplands with a grass-pickleweed (*Salicornia* spp.) mixture. These areas are in the closed zone to hunting. Tule geese observed feeding in the Napa Marsh were found in tidal areas fringed by emergent cattails, tules, alkali bulrush, and cordgrass (*Spartina* spp.) with pickleweed and *Grindelia* spp. in the high areas. Two tule geese taken during hunting season in December 1954 were analyzed for food habits. Results showed alkali bulrush tuber and rhizome fragments in both with forb leafage and insect fragments (Longhurst 1955).

The managed wetlands of the Suisun Marsh are the most important habitat for tule geese in the San Francisco Bay ecosystem. These wetlands, managed for alkali bulrush and other wetland wildlife food plants are critical as feeding and roosting areas as they will feed primarily on tubers and rhizomes of alkali bulrush.

Movement - Generally, studies of daily movement of tule geese in the winter have shown that several subflocks exist (groups with specific roost sites and movement patterns). Subflocks were readily identified utilizing Sacramento NWR during studies in 1979-80 (Wege 1980). This is also probably true in other wintering areas. Birds move between Sacramento and Delevan NWRs, Grizzly Island Wildlife Area, and in the Delta. These same studies indicated that two daily feeding flights were common. At Grizzly Island Wildlife Area, short flights were made from roosting ponds to barley fields (Wege 1980).

During waterfowl hunting seasons (late October to late January), tule geese may develop different movement patterns due to the disturbance. In the Sacramento Valley, after opening of hunting season, tule geese shift to off-refuge harvested rice fields and to closed portions of

Table 6.1 Peak Monthly Population Indices* for Tule Greater White-fronted Goose on Migration, Stopover, and Wintering areas in Oregon and California for 1978-79 through 1981-82, 1988-89, and 1989-90[a]

	Sacramento Complex[b]	Grizzly Island WA	Lower Klamath NWR	Summer Lake WMA	Malheur NWR	Total
1978-79						
Nov.	1300					1300
Dec.	900	1000				1900
1979-80						
Sept.	300		500			800
Oct.	1300	500	25			1825
Nov.	1000					1100
Dec.	1000	800				1800
Jan.	700	500				1200
Feb.	400		300			700
Mar.			500			500
Apr.			500			500
1980-81						
Sept.	1000			1500		2500
Oct.	3000	500	2000			5500
Nov.	3500					3500
Dec.	3000	1500				4500
Jan.						
Feb.						
Mar.						
Apr.			1000			1000
1981-82						
Sept.	500			2100		2600
Oct.	2000	1000	1200			4200
Nov.	3500					3500
Dec.	3500	1200				4700
Jan.						
Feb.						
Mar.						
Apr.			3000			3000
1988-89						
Sept.	5100	85	100-200	644	1830	7809
Oct.	5645	300	100-200	800		6895
Nov.	5450	300		23		5773
Dec.	5300	970				6270
Jan.		1050				1050
Feb.		1229	200			1429
Mar.			500			500
1989-90						
Sept.	3400	100		1875	3240	8615
Oct.	5070	97		850	200	6217
Nov.	6258	557		56		6871
Dec.	6000	890		3		6893
Jan.		913				913
Feb.		1190				1190

* Indices reflect trends and not absolute numbers.
[a] Summarized data represent contributions from cooperators of the Pacific Flyway Study Subcommittee on the Pacific Flyway Population of Tule Greater White-Fronted Geese (principal author G. Menzik). Peak monthly counts include geese recorded in immediate vicinity of indicated survey areas.
[b] Includes Sacramento NWR, Delevan NWR, and Colusa NWR.

refuges (Timm et al. 1982). When not disturbed they generally feed early mornings and late afternoons. During hunting seasons there may be some night feeding (Cogswell 1977).

Conservation and Management

Since the late 1960s, information on tule geese has been gathered on population size and distribution, production, mortality, and harvest. In addition, habitat management and protection practices have been implemented that have included classifying areas as refuge or critical habitat, zoning laws to protect lands important to tule geese, enhancement of state, federal and private lands by controlled burning, grain farming, or marsh management, and using federal easements to provide incentives to private landowners to retain wetlands.

Contaminant Risks - No information.

Disturbance - Most Pacific Flyway tule greater white-fronted goose harvest occurs in California. Despite limited harvest information from band returns or hunter check stations, it appears harvest locations for tule white-fronted geese are similar to those for Pacific white-fronted geese. The 1979-1982 and 1987-1989 sport harvest of tule white-fronted geese on the Sacramento NWR Complex indicate that: (1) tule geese comprise a disproportionately high percentage of the harvest (30-60%) when compared to population composition (5-25%); (2) the majority of the harvest comes from Delevan NWR and adjacent areas; (3) harvest age ratios for tule geese (30%-40% young) more closely reflect those of the population than do those of Pacific white-fronted geese (70%-80% young).

Sport harvest also occurs at Grizzly Island Wildlife Area and Klamath Basin NWR. In addition, kill records indicate 20-30 tule geese are taken by private duck clubs in the Suisun Marsh and 15-20 by clubs in the Napa Marsh (Smith, pers. comm.). Limited harvest has occurred on Summer Lake Wildlife Management Area and Malheur NWR in Oregon. In addition, two tule geese marked in Alaska were shot in southeastern Texas the first year after banding (Timm et al. 1982). Estimated hunting mortality appears to represent less than 5 percent of the known total population. This is supported by the comparatively high survival estimates (>80%) the first year after banding (Timm et al. 1982).

Recommendations

The Pacific Flyway Management Plan for tule geese contains harvest guidelines by region based on population indices. Strategies are based on the objective to maintain stable populations. These basic strategies recommend liberal harvest allowances with the population above 10,000, and with more restrictive regulations until the population index reaches 3,200 when the season would be closed. These strategies are primarily for Sacramento and Delevan NWRs and Grizzly Island Wildlife Area.

Habitat management recommendations include protecting current and future breeding areas as "critical habitat". Acquisition or easement of habitat areas in California and Oregon not currently under state or federal management is recommended. Management practices on state, federal, and private lands beneficial to tule geese should be maintained.

Within the San Francisco Bay Area, the areas of greatest importance to the tule goose are Suisun and the North Bay. Important habitat elements are open water, perennial and seasonal pond, high tidal ecotone (in Napa Marsh), and emergent vegetation. Fringe marsh along sloughs is also important. Regionwide, goals to support this species should include maintaining current acreages of managed marsh, managed upland habitat, and farmed upland areas that are farmed for oat hay.

Suisun - Suisun is the most important subregion for all goose species. To maintain current population levels, we need to maintain their habitat - managed wetlands and associated upland habitat.

North Bay - Tule geese do not nest in this Estuary, but an associated species, the Canada goose, nests in the Napa Marsh of the North Bay. Currently, the North Bay has a relatively small wintering population of tule geese and Pacific greater white-front geese, but they seem to be adjusting to the habitat gains recently made in the area (Petaluma, etc.). There is potential to increase goose populations with a further increase in managed marsh habitat. Areas of importance in the North Bay include the Napa Marsh from Sears Point to Napa River, Salt Ponds 1A and 1AN, all managed marsh areas, seasonal ponds in agricultural areas, farmed uplands, and the high tidal ecotone. Current acreages of farmed and managed upland habitat should be maintained.

Central Bay - Tule geese do not currently use this subregion in great numbers, but an increase in habitat (managed marsh and managed upland habitat) could increase the subregional population. The San Pablo Reservior is important for Aluetian Canada geese.

South Bay - Tule geese do not currently use this subregion in great numbers, but an increase in habitat (managed marsh and managed upland habitat) could increase the subregional population.

Research Needs

Comprehensive research occurred during the late 1970s and early 1980s. Work was conducted on wintering, migration stopover, and the newly discovered breeding areas. Activities included leg banding, neck collaring, and outfitting individuals with radio transmitters. Daily and seasonal movements were monitored, sport harvest documented, and social behavior observed (Timm et al. 1982, Wege 1984).

Future research should address several aspects of the tule greater white-fronted goose ecology. Winter habitat requirements would help land managers develop strategies to protect and enhance wetlands for tule geese. Additional data is needed to develop techniques for subspecific identification. There is relatively good information on sport hunting mortality, however there is a distinct lack of data on non-sport hunting mortality due to disease, predation, subsistence hunting, and pollution. Continued improvement of fall/winter surveys will aid in obtaining concurrent peak population counts and age ratio samples on all known use areas.

Additional needs center around data gaps that are intensified by the small population size of tule geese and their physical similarity to Pacific greater white-fronted geese. Regularly scheduled surveys are needed to help answer the population status question. A better understanding of the taxonomic differences between Pacific

greater white-fronted geese and tule greater white-fronted geese is needed. Estimates of production, survival, and mortality parameters are incomplete. Past research needs to be completed with analyzed and published results. Effects of some agricultural land use practices are not known. Habitat requirements are not fully delineated. There is sport harvest occurring outside of California but the magnitude and location of harvest, and thus complete wintering population size, is also unknown. (Mensik 1991).

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Mallard

Anas platyrhynchos

Steven C. Chappell
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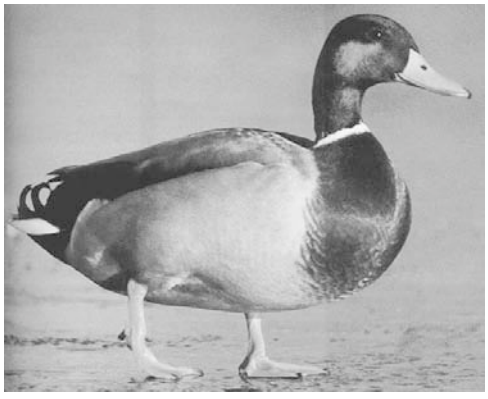
Introduction

The mallard was selected as a representative of other dabbling ducks such as Cinnamon teal (*Anas cyanoptera*) and Gadwall (*Anas strepera*) which are found in the Suisun Marsh and the San Francisco Bay Area. All three of these species represent resident breeding populations in the San Francisco Bay Estuary, as well as migrational wintering populations from the northern breeding grounds.

The largest population of mallards occur in the Suisun subregion. Mallards were also recorded as the number one dabbling duck of the San Pablo Bay and South San Francisco Bay subregions, most often using seasonal wetlands habitats and low salinity salt ponds. The lowest numbers of mallards were recorded in the Central Bay subregion, with few mallards being recorded in the open bay habitats of all four subregions.

Description

The mallard is one of the most easily recognizable of all waterfowl species. The drake is characterized by a bright yellow bill, brilliant green head, and brown chest with a white neck ring separating the two. The drakes also have a gray body with central black tail feathers curling upward. Both sexes have white outer tail coverts, with a blue speculum bordered in white, and bright orange feet. The female is the typical mottled brown of other *Anas* species, and has an orange bill with a dark spot on top. Mallards are among the most vocal of all duck species. The hen mallard has a call which begins with a loud quack followed by a series of slowly diminishing quacks. The drake mallard, by comparison, has a very soft almost buzzing call. Adult male mallards typically average 24.7 inches in length and weigh 2.75 pounds, while the female tends to be a little smaller at an average of 23.1 inches and weigh 2.44 pounds (Bellrose 1980).



Courtesy USGS/NBS

Breeding Biology - Mallards have one of the most widespread breeding ranges of all waterfowl species, encompassing both Canada and the United States. Loose pair bonds begin to form as early as August (Barclay 1970) with nesting beginning by early April. The pair bond generally begins to weaken with the onset of incubation, rarely lasting until pipping (pre-emergence). Nesting typically occurs on the ground, in upland fields generally in stands of dense vegetation. The nest is a shallow depression in the vegetation that is lined with down and feathers plucked from the females breast. The typical clutch size is from 7-10 eggs, but can be as high as 15. Females incubate the eggs for approximately 28 days, and are the primary care provider for the ducklings which are precocial at hatching, and move about the nest in a few hours (Batt et al. 1992).

Migration Ecology - Migration occurs along four different flyways, with the heaviest used corridors being the Mississippi Flyway in the East, and the Pacific Flyway in the West (Bellrose 1980). Birds migrating to northern breeding grounds depart the wintering areas by early February, returning as food availability becomes scarce, and arriving back in the wintering grounds by early October. The most important migration corridor in the West appears to be from Alberta to the Columbia River basin with several different routes going into the Central Valley of California (Bellrose 1980).

Wintering Ecology - Mallards primarily winter throughout the United States and along the west coast of Canada, with the Atlantic flyway attracting relatively few numbers of birds (Bellrose 1980). Suisun, San Francisco Bay, the Sacramento-San Joaquin Delta, and the Central Valley are important wintering areas for the mallards in the Pacific flyway. These areas also provide important stop-over locations for mallards migrating to and from the wintering and breeding grounds.

Distribution and Abundance

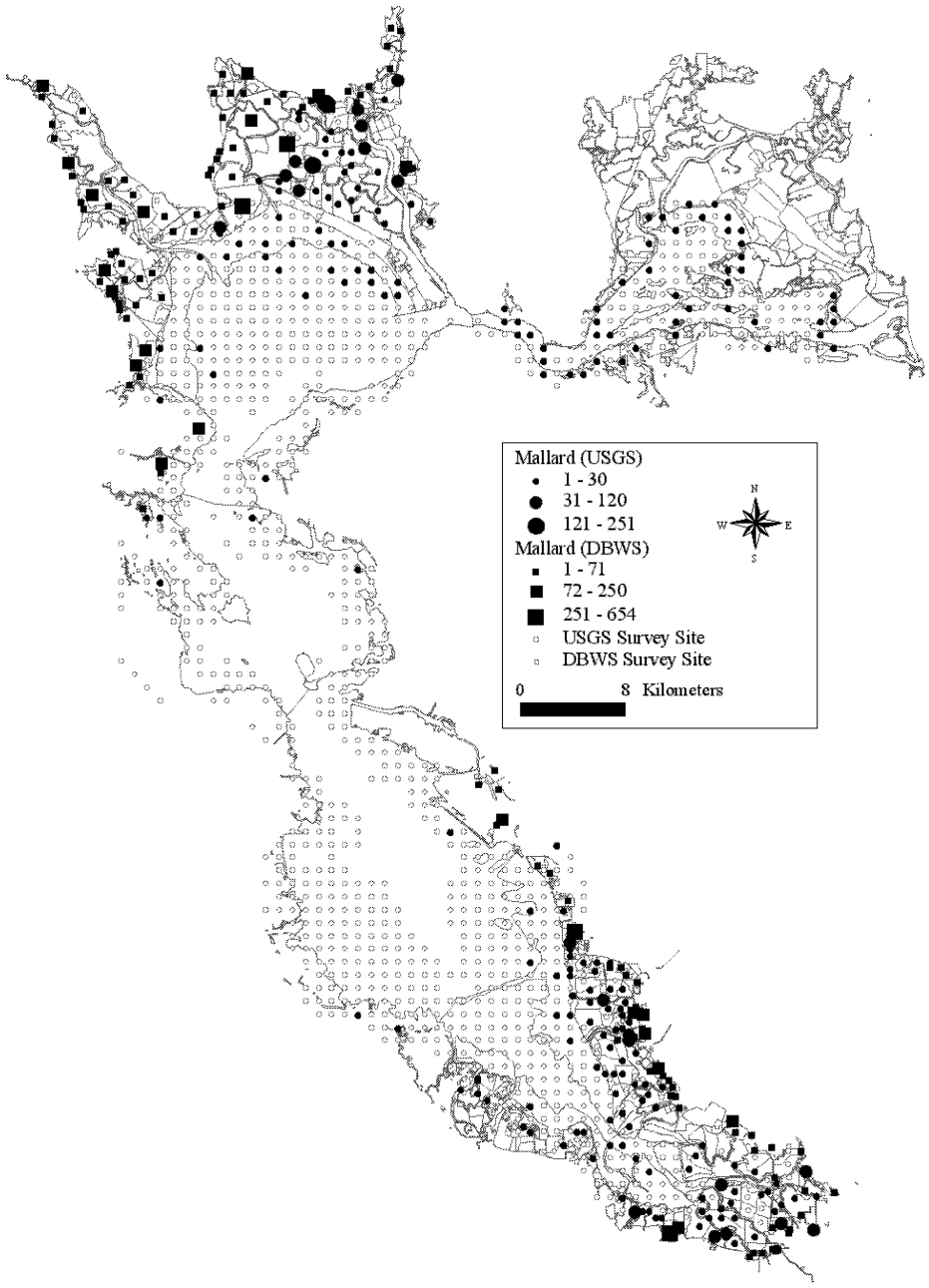
North America - Mallards are the most widely distributed species of waterfowl in North America, and are found virtually everywhere in high numbers except for the Atlantic Flyway. During the 1996-1997 waterfowl season, mallard numbers in the Suisun Marsh fluctuated from a high of 29,580 on October 16, 1996, to a low of 6,105 on January 8, 1997 (CDFG 1997). Some of the primary factors influencing mallard distribution in the San Francisco Bay Estuary is the availability of areas with low salinity water, and the necessary food resources. Accurso (1992) found that the mallards were using the salt ponds in the North and South bays at 2-3 times the expected rate based on availability. These ponds had a salinity level of around 20-33 ppt.

Pacific Coast - No information.

Figure 6.2 Maximum Counts of Mallard

Open water data from the USGS Study of Waterfowl in Open Bays and Salt Ponds, 1988-1990 (USGS, unpubl.), John Takekawa (unpubl. data), and Accurso 1992.

Bayland data from the Diked Baylands Wildlife Study (DBWS),1982-1989 (USFWS, *in prep*.).



San Francisco Bay - In the Diked Baylands Wildlife Study (USFWS, *in prep.*), mallards were identified as the dabbling duck using seasonal wetland habitats most often in the greatest numbers for both the North and South bays. **Figure 6.2** shows the distribution of mallards around the Bay.

Historical Information

No information.

Population Trends

Since 1960 the continental population of mallards has fluctuated widely from an overall high in 1970 of 9,986,000 birds to a low of 4,960,000 birds in 1985. During the ten year period since 1985, however, the trend in mallard numbers has been an increase to a high of 8,269,000 birds in 1995 (CDFG 1953-1997 and 1997). In 1996 and 1997, there has been a decrease in mallard numbers down to 7,643,000 (CDFG 1997). The overall Suisun Marsh mallard population has fluctuated widely since 1960 with a high of 88,885 mallards to a low of 10,876 mallards. Several years have large peaks in the total number of mallards using the marsh, which could indicate the arrival of migrants from the northern breeding grounds.

Habitat Use and Behavior

Foraging - Mallards are very opportunistic in their foraging behavior. They will feed on both natural food

plants, as well as agricultural waste grains while on the wintering grounds. The primary natural foods eaten by waterfowl in the Suisun Marsh are alkali bulrush, fathen, brass buttons, watergrass, and smart weed (Rollins 1981). Aquatic invertebrates play an important role in mallard diets prior to and during the breeding season, due to the high energy demands of the hen for egg laying.

Breeding - Nest site selection begins once the flock reaches the breeding grounds, with the pairs breaking off from the flock and setting up independent home ranges. The home range will typically include one or more loafing sites consisting of bare shore surrounded by tall standing vegetation near water (Bellrose 1980). Mallards use a wide variety of vegetation types in the construction of their nests. In the Suisun Marsh the primary vegetation used is annual rye grass, lana vetch, brome, and tall wheat grass, as well as natural wetland plants within the managed wetlands. The main nesting requirement appears to be that the vegetation is dense and approximately 24 inches tall.

McLandress et al. (1996) found that the mallard nest densities in the Suisun Marsh, Central Valley, and the intermountain region of Northeastern California were higher than in the prairie breeding grounds in Canada. Canadian nest densities were found to average 10.6 mallard nests/kmý. In California mean nest densities ranged from 41 nests/kmý in the San Joaquin Valley to 190 nests/kmý in the Suisun Marsh.

Yarris et al. (1994) determined, using radiotelemetry, that some hens nesting at Grizzly Island Wildlife Area will leave the area after fledging their young, and prior to their wing molt. Yarris detected radio-tagged hens in the Delta east of Grizzly Island Wildlife Area and as far north as the southern Oregon border, locating the molting areas of 20 hens. All hens radio-tagged were detected moving in a northerly direction shortly after leaving the Suisun Marsh. Mallard ducklings are very sensitive to increasing salinity levels. Mitchum and Wobster (1988) found that water with a specific conductivity of 20 mS/cm is lethal to mallard ducklings, and ducklings exposed to 4 mS/cm will experience impaired growth.

Roosting - Mallards commonly roost in ponded areas of managed wetlands with tall emergent vegetation, but may be regularly seen loafing in open Bay habitats as well as salt ponds.

Movement - No information.

Conservation and Management

Contaminants - Disease and contaminants are directly responsible for a large amount of the waterfowl mortality each year, although the total number is unknown. Diseases such as botulism, cholera and duck viral enteritis historically have not been a major concern for duck populations in the Suisun Marsh. The only major event has occurred in this region during the winter of 1948-49 when approximately 40,000 ducks, geese, and coots died in an avian cholera outbreak in the San Francisco Bay Area (Bellrose 1980). As with all places that have historically used lead shot, there is still a possibility of incidental mortality due to lead poisoning. The danger of this disease is not that there is a large noticeable die-off every year, it is that no one knows how many individual birds ingest lead and die without ever being noticed. Bellrose (1959) concluded that 2 to 3 percent of the fall and winter waterfowl populations may fall victim to lead poisoning each year. With the current use of non-toxic shot loads in waterfowl hunting, this number should gradually become smaller as the old exposed lead shot is covered by sediment and becomes unreachable.

The maintenance of good wintering and breeding habitat in the Suisun Marsh and Napa Marsh is important to the continued use of the San Francisco Bay Estuary. This can be accomplished by the protection of seasonal wetlands and the intensive management of diked managed wetland areas.

Disturbance - Disturbance from human activities can cause temporary changes in behavior and locally affect temporal and spatial distribution of migratory and wintering waterfowl (Madsen 1994) Disturbance by humans caused both longer duration of alert and flight behavior by pintail when compared to disturbance by raptors or other animals (Wolder 1993). Considering these disturbance impacts could be similar to mallards, activities such as wildlife viewing, urbanization, and vehicle traffic may have negative effects.

Recommendations

Managed wetlands are critical habitat for both resident breeding birds and for migrants, as they provide food resources and wintering habitat. Within the region, the most important areas for mallards are the managed wetlands of Suisun Marsh, some less saline areas of San Pablo Bay, and seasonal wetlands habitat around the San Francisco Bay. To support mallards, regional goals should strive to increase the acreage of managed marsh habitat; maintain or enhance current areas of lagoon (loafing and feeding habitat) and farmed baylands (critical wintering habitat); and maintain diked marsh (especially in brackish areas), ruderal baylands (breeding and nesting habitat), low salinity salt ponds, and treatment ponds. Adjacent to the baylands, grazed and managed uplands should be maintained and increased as critical breeding habitat, and riparian habitat should be improved and increased.

Important habitat elements for mallards include seasonal ponds (most critical for food production for wintering birds); perennial pond (wintering and breeding habitat, foraging); water column/open water (loafing); clay-silt substrate (foraging); mudflats (limited use); veg-

etated levees and islets (nesting); eelgrass (very minor on the open bay); pan (if brackish, important for wintering, foraging, breeding); emergent vegetation; riparian zone community; vernal pools (fresh water); and artifactual vernal pools.

Suisun - The managed marshes of Suisun are the most important habitat for mallards in the San Francisco Bay. Riparian habitat is also important. Specific habitat goals for the Suisun subregion include increasing the acreage of managed marsh, diked marsh, ruderal baylands, and managed uplands; maintaining and enhancing farmed and grazed baylands; and maintaining grazed upland and riparian areas. In this subregion salinity levels preclude increasing riparian zones.

North Bay - Areas of particular importance in this subregion are the managed wetlands of the Napa River area and low salinity salt ponds. Subregional habitat goals include increasing the acreage of managed marsh, lagoon, and low salinity salt ponds; maintaining and enhancing farmed and grazed baylands; and maintaining diked marsh and ruderal baylands. Adjacent to the baylands, managed uplands and riparian zones should be increased and enhanced.

Central Bay - The Central Bay does not currently have a large population of mallards; to increase this population, critical mallard habitats (managed marsh and upland) should be increased. Areas of particular importance within this subregion are lagoons and the wetlands near Marin. Habitat goals for the Central Bay include increasing the acreage of managed marsh and lagoon, and maintaining areas of diked marsh and ruderal baylands. Adjacent to the baylands, managed uplands and riparian zones should be increased and enhanced.

South Bay - Areas of particular importance within the South Bay are managed wetlands, low salinity salt ponds, and diked wetlands. Riparian zones also show some usage by mallards. Habitat goals for the South Bay subregion include increasing the acreage of managed and diked marshes; maintaining and enhancing farmed baylands; and maintaining ruderal baylands and low salinity salt ponds. Adjacent to the baylands, managed uplands and riparian zones should be increased and enhanced.

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Northern Pintail

Anas acuta

Michael L. Casazza
Michael R. Miller

Introduction

The northern pintail has been historically the most common puddle duck wintering in the San Francisco Bay region. Continental population declines have been severe and the declines have been even greater within the San Francisco Bay region. This disproportionate decline in pintails using the San Francisco Bay region is alarming and needs further investigation. In particular, the Suisun Marsh has seen peak numbers decline as much as 90% over the past several decades (**Figure 6.3**). Pintails use a wide variety of habitat types throughout the region, including managed marsh, seasonal wetlands, open bay, and salt ponds. They utilize many of the habitats used by other waterfowl species. Species which are commonly found in similar habitats as pintail are greenwing teal (*A. crecca*), northern shoveler (*A. clypeata*), and American wigeon (*A. americana*). We have grouped these three species together with pintails, but the pintail will be the focus as the key species because it is relatively abundant in the San Francisco Bay region, and it uses many different habitat types, including managed wetlands, as critical wintering areas.

Description

The northern pintail is a long slender duck with narrow, angular wings. Pintails float high on the water, offering a very elegant appearance to the casual observer. They have sexually dimorphic plumage. Drakes in nuptual plumage have a chocolate brown head with a white breast and foreneck extending upward as a stripe on each side of the head. Their backs are greyish in appearance and they have two, long black tail feathers for which they are named. Drakes have a distinctive iridescent black-green to green speculum. The male pintail has a distinct short whistle which is heard most during winter and spring. Hen pintails are mottled brown and have a noniridescent brown to brown-green speculum. The bills of both sexes are blue-gray in color with black along the central ridge in males and black blotches in females. Both sexes have gray legs and feet. The male pintail has a total length of between 57-76 cm, and females between 51-63 cm (Austin and Miller 1995).

Courtesy USGS/NBS

Breeding Biology - Under favorable wetland conditions pintails will breed in their first year. They have been known to lay as few as three and as many as 14 eggs, but their average clutch size is about eight eggs (Bellrose 1980). Pintails have been found nesting across a vast area encompassing much of the Northern Hemisphere. Their main breeding areas in North America include the prairie pothole region of Alberta, Saskatchewan, Montana, and the Dakotas, along with the arctic regions of Canada and Alaska. In California, pintails nest on the northeastern plateau, the San Joaquin Valley, and on the coastal marshes, including Suisun Marsh and San Francisco Bay. Their nests tend to be in relatively open cover and can be as far as 3 km from water (Duncan 1987). Pintails are early nesters, some initiating their nests as early as late March, depending on weather conditions and location.

Migration Ecology - The major North American migration routes range from breeding areas in northern Alaska and the prairie pothole region south to California, Mexico, Texas, and Louisiana. Pintails begin arriving on wintering areas in early August. They are also one of the first ducks to leave wintering areas, as early as mid-February, to begin migration to breeding grounds.

Wintering Ecology - California is the most important wintering area in North America, and more pintails winter here than anywhere else in the Northern Hemisphere (Bellrose 1980). Other important wintering areas include the West Coast of Mexico and the Gulf Coast regions of Texas and Louisiana.

Distribution and Abundance

North America - The 1997 breeding duck survey conducted by the U.S. Fish and Wildlife Service found 3.6 million pintails in North America, which was a significant (30%) increase over 1996, but still 19% below the long-term average (Dubovsky et al. 1997).

Pacific Coast - Pintails are known to winter throughout the Pacific Coast region, and nest here in limited numbers. Important wintering areas include the coastal marshes of British Columbia, Puget Sound, the Lower Columbia River basin, the Willamette Valley, and the northern coast of California. The inland valleys of California are the most important wintering area for pintails.

San Francisco Bay - Mid-winter surveys conducted in January each year have indicated a great de-

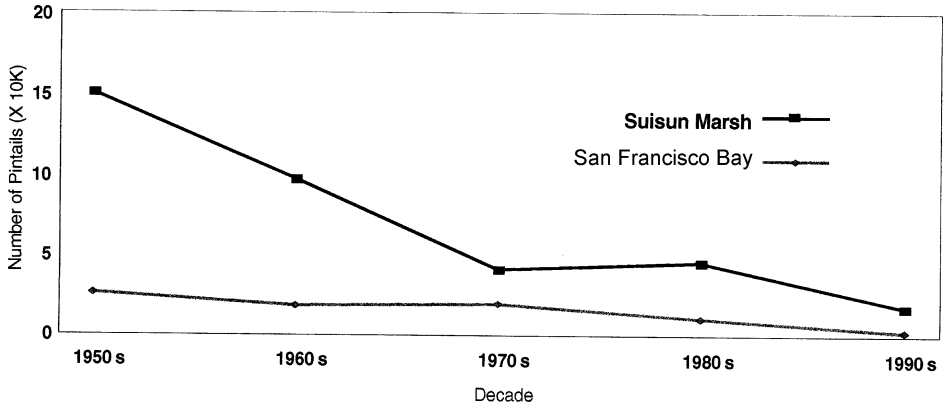

Figure 6.3 Mean Mid-Winter Survey Counts of Pintails by Decade in Suisun Marsh and San Francisco Bay (CDFG unpublished survey data)

cline in pintail numbers within the San Francisco Bay region, with the greatest proportion of that decline occurring in the Suisun Marsh (**Figure 6.3**). In the 1950s, there were close to 200,000 pintails wintering in the San Francisco Bay region, whereas the 1990s have averaged under 20,000, a decline of 90 percent.

Suisun - Northern Pintails winter in significant numbers in Suisun Marsh. Some pintails may roost on the open bays in this region (**Figure 6.4**), but most are found on managed seasonal wetlands (CDFG 1953-97). A radio telemetry study conducted from 1991-93 found pintails widely distributed throughout the managed wetlands of Suisun, with some distinct high use areas (**Figure 6.5**). The Suisun Marsh consists of approximately 23,000 hectares of marshlands and 9,300 hectares of bays and waterways and is the largest contiguous estuarine marsh in the United States (Miller et al. 1975). The majority of the pintails wintering in the San Francisco Bay region can be found in this area.

North Bay - Waterfowl surveys conducted between 1988-90 in the San Francisco Bay area indicated that North Bay salt ponds held 13-19% of the pintails (not including the managed wetlands of Suisun Marsh) (**Figure 6.4**). Open waters of the North Bay accounted for 12% of the region's pintail population in 1988-90 (Accurso 1992). Diked baylands of the North Bay had significant numbers of pintails during the winter period (**Figure 6.4**).

Central Bay - Very few pintails were observed on the Central Bay between 1988-90 (**Figure 6.4**).

South Bay - South bay salt ponds held 60-67% of the pintails wintering in the San Francisco Bay region from 1988-90 (not including the managed wetlands of Suisun Marsh), while open waters of the South Bay received very little use by pintails (**Figure 6.4**).

Historical Information

Comprehensive waterfowl surveys have been conducted since the mid-1950s which include much of the pintails primary range. Population trends and estimates are available since that time.

Population Trends

Nationally, current pintail population estimates have increased somewhat from the all-time low of 1.8 million in 1991, and are well below goals established by the North American Waterfowl Management plan (5.1 million) (Caithamer and Dubovsky 1997). The number of pintails wintering in California has decreased dramatically from long-term averages. Locally, pintail use of the San Francisco Bay Area has declined in even greater proportion than the overall population decline.

Habitat Use and Behavior

Pintails are known to use a variety of habitats within the San Francisco Bay region, including diked fresh and estuarine wetlands, salt ponds, open bays, and mudflats (Cogswell 1977, Accurso 1992, Casazza 1995). Within the managed seasonal wetlands of the Suisun Marsh, pintails prefer to feed in habitats dominated by brass buttons (*Cotula coronopifolia*), a perennial salt tolerant herb introduced to the Bay in the late 1800s (Casazza 1995).

Foraging - Several studies have been conducted on the feeding ecology and diet of northern pintails, but none have included San Francisco Bay, and studies conducted in Suisun Marsh are outdated. Pintails are adept at separating small seeds from bottom sediments in aquatic habitats, and regularly feed on small seeds (Krapu 1974). Pintails use their long necks and tipping style to feed on or near the bottom of ponds and to utilize the benthos and seeds present at shallow depths (Krapu 1974). Pintails can exploit food sources to depths of 40 cm (Thomas 1976).

The winter diet of northern pintails consists primarily of seeds and vegetative material, with important seeds including rice (*Oryza*), swamp timothy (*Heleochloa*

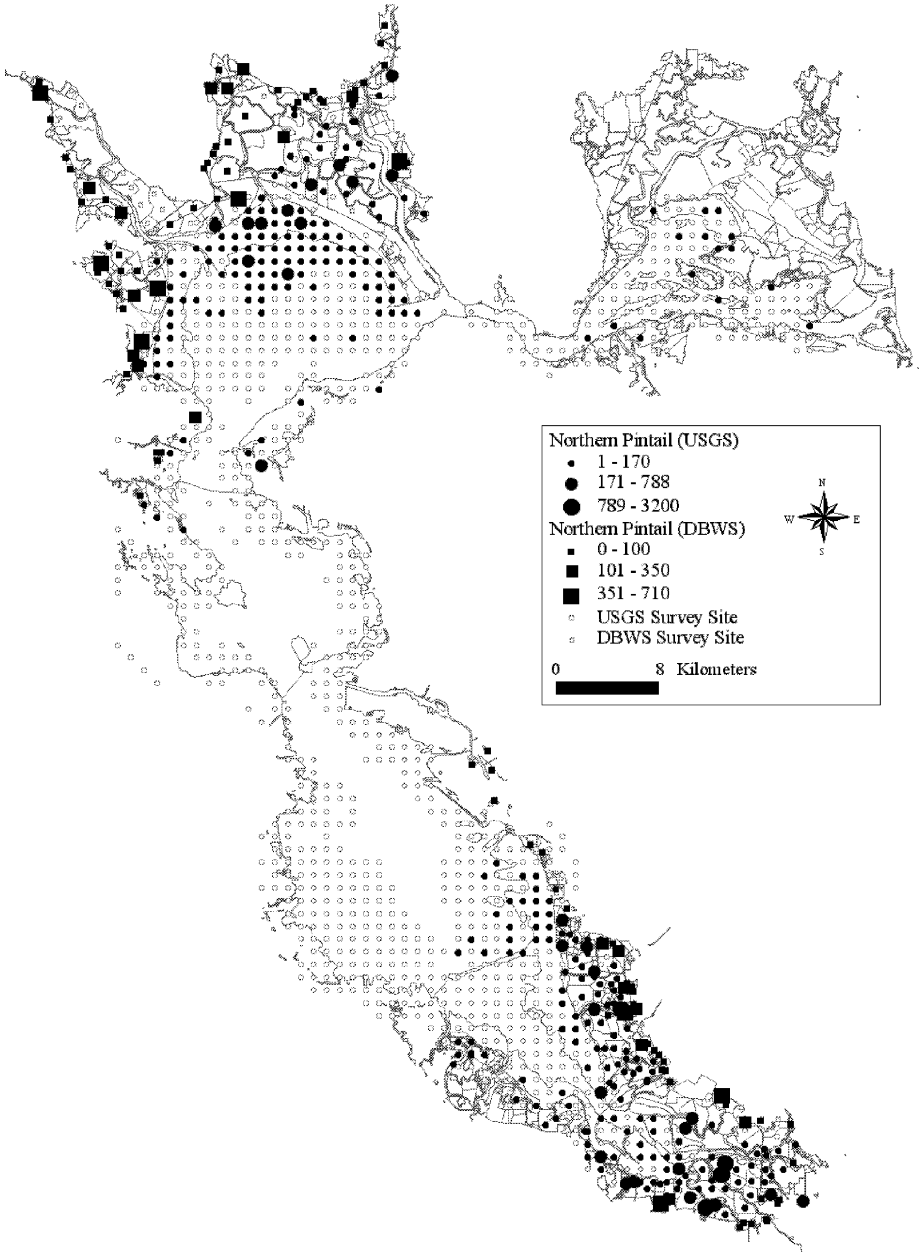

Figure 6.4 Maximum Counts of Northern Pintail

Open water data from the USGS Study of Waterfowl in Open Bays and Salt Ponds, 1988-1990 (USGS, unpubl.), John Takekawa (unpubl. data), and Accurso 1992.

Bayland data from the Diked Baylands Wildlife Study (DBWS),1982-1989 (USFWS, *in prep.*).

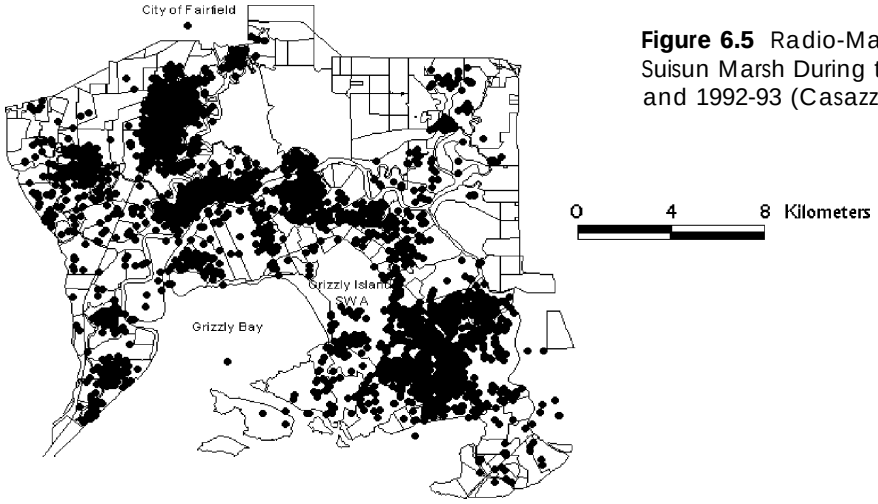

Figure 6.5 Radio-Marked Pintail Locations in Suisun Marsh During the Fall and Winter of 1991-92 and 1992-93 (Casazza 1995)

schenoides), barnyard grass (*Echinochloa crusgalli*), flat-sedges (*Carex* spp.), southern naiad (*Najas guadalupensis*), and smartweeds (*Polygonum* spp.) (Austin and Miller 1995). Miller (1987) found that plant foods accounted for nearly 100% of the diet of pintails in the Sacramento Valley in early fall, and by late winter their diet had shifted to about 40% animal matter, primarily midge larvae. In the Suisun Marsh, pintail gizzards were found to contain three main marsh seeds; brass buttons (*Cotula coronopifolia*), alkali bulrush (*Scirpus maritimus*) and fat hen (*Atriplex triangularis*) (George et al. 1965).

Roosting - Pintails roost on open water habitats, including lakes and bays, which lack extensive emergent vegetation. Pintails commonly roost on open water areas of all four regions of San Francisco Bay (**Figure 6.4**).

Movement - Pintails commonly make local and regional movements. Local movements primarily consist of evening and morning flights between roost and feeding areas, usually less than 5 km. Soon after sunset in the Suisun Marsh, radio-marked hen pintails would commonly leave open water sanctuary areas such as Joice Island, to make 1-3 km flights to feeding areas on nearby private duck clubs (**Figure 6.6**). Regional movements occur when pintails leave an area and establish new feeding and roosting sites, usually encompassing distances greater than 10 km. Radio-marked pintails commonly left the Suisun Marsh and established new feeding and roosting sites in the Delta, and the Sacramento and San Joaquin valleys (Casazza 1995). Only one radio-marked pintail moved to San Francisco Bay from Suisun Marsh during two years of study (Casazza 1995).

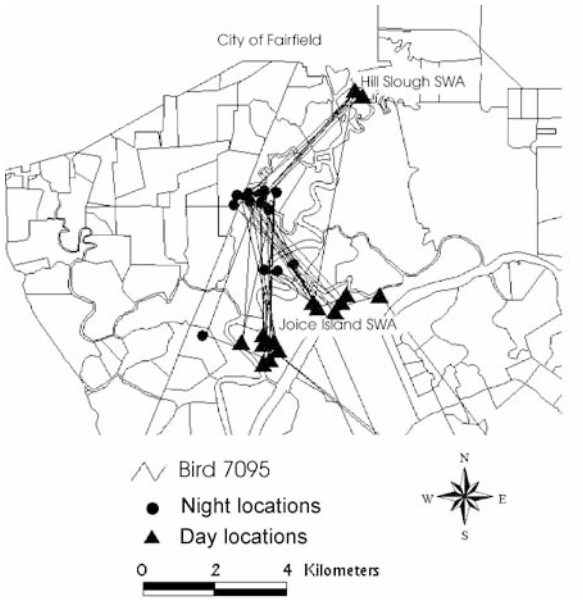

Figure 6.6 Common Day and Night Movement Patterns for Pintails Wintering in Suisun Marsh (Casazza 1995)

Conservation and Management

Contaminant Risks - Little information is known about exposure of pintails to contaminant risk in the San Francisco Bay region. Health warnings are published for greater and lesser scaup (*Aythya marila* and *A. affinis*) and surf scoters (*Melanitta perspicillata*) harvested in the San Francisco Bay region, and further investigation of contaminants in pintails is warranted. Ohlendorf and Miller (1984) found that pintails seemed to accumulate chemicals such as DDE while wintering in California, and similar accumulations of contaminants may take place in birds wintering in the San Francisco Bay region.

Disturbance - Disturbance of northern pintails was studied by Wolder (1993) on Sacramento National Wildlife Refuge in the Sacramento Valley of California. He found that human disturbance was a major factor in pintail distribution. Disturbances by humans resulted in longer time spent alert or flying than disturbances caused by raptors or other animals (Wolder 1993). Common types of disturbance include vehicle traffic, wildlife observation, and hunting.

Recommendations

Suisun currently provides critical support for pintails. North Bay and South Bay also are used by these birds. Managed marsh is the most critical habitat type for pintails in the Estuary, and for Suisun in particular, for most of winter. Uplands puddled from rain and seasonal ponding provide critical late winter/spring habitat for pintails in this region. Many of the other habitat types, such as diked marsh and muted tidal marsh, would provide even better habitat if managed for dabbling ducks. Intertidal mudflats are important feeding habitat when covered by 10-40 cm of water. Unvegetated levees and islets are important roosting habitats.

Regional goals to support pintails include increasing the acreages of managed marsh and low salinity salt ponds; maintaining and enhancing mid-tidal, muted tidal (if managed for water fowl), and diked marsh; and maintaining the acreage of intertidal flat and shallow bays. Seasonal ponds in farmed and grazed baylands should be maintained or enhanced, and mid-salinity salt ponds should be maintained but converted to low salinity. Adjacent to the baylands, irrigation ponds in farmed uplands should be maintained, and managed upland habitat should be maintained for nesting.

Suisun - All managed marsh habitat within the Suisun subregion is important to support pintails. Goals within this subregion should include maintaining the current acreages of muted tidal and managed marsh, intertidal flat, shallow bays or straights, and managed uplands. To best meet the needs of pintails, muted tidal marsh, diked marsh, and managed marsh should be managed for water levels, vegetation, and timing of flooding

most beneficial to dabbling ducks. Specifically, open water 10-40 cm deep with brass button-type vegetation is best.

North Bay - North Bay salt ponds were an important habitat for pintails. Survey data indicates that at least 1000 hectares (ha) of salt ponds should be maintained to ensure at least 80% of the current use by pintails in this region. In particular, ponds 1AN, 2, 2N, and 6N had a significant amount of use by pintails. Other important areas include Slaughterhouse Point; American Canyon Marsh; the mudflats near Sonoma Creek; open, shallow water near mudflats; Point Richmond Bay; and Tubbs Island lagoon. Goals to support pintails within the North Bay include maintaining current muted tidal marshes and diked marshes and enhancing them by managing them for ducks; maintaining mid-tidal marsh, low salinity salt ponds, ruderal baylands (used for nesting), intertidal flat, and shallow bays or straights. Ponding should be enhanced in farmed or grazed baylands and adjacent uplands. Mid-salinity salt ponds should be converted to low salinity ponds, and managed upland habitat should be maintained to provide nesting habitat. Increasing managed marsh habitat would support an increase in pintail population.

Central Bay - Important areas include Point Richmond Bay mudflats, Albany mudflats, and the Emeryville Crescent. To support increased populations of pintails in the Central Bay, the current acreage of managed marsh should be increased.

South Bay - South Bay salt ponds held 60-67% of wintering pintails of the San Francisco Bay (not including Suisun) from 1988-90. Survey data indicates that at least 2,100 hectares (ha) of salt ponds should be maintained to ensure at least 85% of the current use by pintails in this region. Areas of critical importance to pintails include the Sunnyvale sewage pond, and Ponds A9 and A10. Other important areas include Ponds A3W, B3C, M1, A, and NA1; Mowry Slough; Charleston Slough; Faber Tract; the shallows near the east end of the Dumbarton Bridge; Coyote Slough; the Hayward ponds; and the Hayward treatment ponds. Goals to support pintails would include maintaing the current acreage of low salinity salt ponds and increasing it by coverting mid-salinity ponds; maintaining the current acreage of mid-tidal marsh, intertidal flat, and shallow bays and straights; and maintaining and enhancing the current acreage of muted tidal marsh and diked marsh by managing for ducks. The current acreage of managed marsh should be maintained, or else increased to increase pintail populations.

Research Needs

The disturbing decline of pintail abundance in the San Francisco Bay region needs immediate attention. Studies need to be implemented which will identify management practices that can be used to attract pintails to the region and provide a solid habitat base for these waterfowl throughout the winter. Other factors that should be investigated include effects of disturbance and contaminants on pintail abundance in this region.

Acknowledgments

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Canvasback

Aythya valisineria

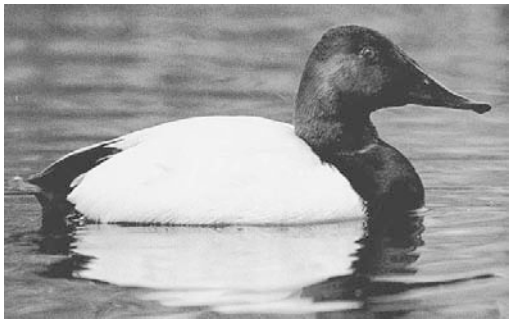
John Y. Takekawa
Carolyn M. Marn

Introduction

The canvasback is a diving duck that forages on aquatic plants or benthic invertebrates in mouths of rivers or channels, large wetlands, and brackish marshes. The continental population of canvasbacks has not increased greatly in the last 20 years, and based on mid-winter surveys (USFWS, unpubl. data), the population in the Estuary has continued to decline. Consequently, the canvasback is a species of special concern for the U. S. Fish and Wildlife Service, and protection of this species was one of the reasons for establishment of the San Pablo Bay National Wildlife Refuge. Associated species that use similar habitats in the Estuary include: common goldeneye (*Bucephala clangula*), greater and lesser scaup (*Aythya marila* and *A. affinis*), which also have declining continental populations, and very small populations of redhead (*A. americana*) and ring-necked ducks.

Description

The canvasback is one of our most distinctive waterfowl species and a member of the Tribe Aythyini. They have a steeply sloping bill with a body size similar to the mallard (0.9-1.6 kg; Cogswell 1977). Males are distinguished by their white back, underparts, and wings, black tail and breast, and red head with blood-red eyes. Females have a brown head and eyes, and a brown or dusky gray body. Redheads are similar in appearance, but have a shorter bill, and redhead males are darker. Canvasbacks are the fastest flying large duck in North America (Bellrose 1980). Their call is a weak "ik-ik-coo" (Cogswell 1977).



Courtesy USGS/NBS

Breeding Biology - Canvasbacks pair during migration in March and April (Erickson 1948, Bellrose 1980). Females will breed as yearlings, but generally less successfully than in later years (Hochbaum 1944, Olson 1964, Trauger 1974). Canvasbacks are well known for their strong fidelity to natal breeding areas (Trauger 1974). Females spend one week searching for a nest site, two to three days to build the nest, and one day laying each egg. Nests occur commonly in shallow ponds of less than one acre covered by cattail and bulrush (Trauger and Stoudt 1974); however, their overlapping home ranges may reach 1,300 acres. Canvasbacks nest in deep water (greater than 6-24 inches) in ponds, marshes, sloughs, and potholes (Trauger and Stoudt 1974). They nest in late April and early May (peak, mid-May) and incubate for 24-29 days. Nest success averages 46.2%, but it is highly variable at different sites, depending on predation by raccoons, mink, skunks, coyotes, fox, weasels, crows, and magpies and desertion following flooding or parasitic laying. As much as 57% of the nests may be parasitized, primarily by redhead ducks (Trauger and Stoudt 1974). Average clutch size is 7.9 eggs, but more eggs (9.5) are found in unparasitized nests. Nest success may be as low as 17% in dry years (Serie et al. 1992), but varies from 17-62% in southwestern Manitoba (Serie et al. 1992). Renesting may occur as much as 50% of the time. Broods are reared in open, large, deep-water areas, but survival averages 25% over the first two months. The 55% of successful hens rear an average of 5.3 fledged young. Non-breeding birds form flocks in late June and July. All birds have a 3-4 week flightless wing-molt during late July and August.

Migration Ecology - Canvasbacks begin their autumn migration in September and arrive in wintering areas in early November. Their spring migration begins in February until their return to breeding areas in April. Major migration routes occur along the Upper Mississippi River and Great Lakes to the Atlantic and Gulf Coast regions, and along the Pacific Coast and Intermountain west to the west coast and Mexico. Significant migration areas in the west include Puget Sound, Great Salt Lake, Malheur and Klamath Basin National Wildlife Refuges and Carson Sink in the Great Basin. During the past two decades, use of staging areas has increased at Pyramid Lake, Klamath Basin National Wildlife Refuges while use of the Great Salt Lake, Malheur and Stillwater National Wildlife Refuge has decreased.

Wintering Ecology - Birds arrive on wintering areas in late October and increase in numbers through

December. Nearly 90% of canvasbacks produced in Alaska winter in California (Lensink 1964). The largest wintering population of canvasbacks is on the Atlantic Coast (290,000), with the greatest number on the Chesapeake Bay. A large number of birds winter along the Gulf Coast in the Mississippi River Delta and Catahoula Lake. Western wintering areas include Lake Earl in Humboldt County, the Columbia and Snake river basins, Carson Sink, the Central and Imperial valleys, and San Francisco Bay. San Francisco Bay is the major wintering area for the western population with 60,000 birds counted in 1960-1971, but only about 25,000 birds counted in 1990. Canvasbacks exhibit high winter site fidelity to the Estuary (Rienecker 1985) and generally winter in more saline areas than redhead ducks.

Distribution and Abundance

North America - Canvasbacks breed in the Arctic and Subarctic, and in the prairie and parkland areas of North America. Approximately 190,000 canvasbacks are found in the parkland areas, with a peak of 10 pairs per square mile with up to 10% of the continental population near Minnedosa, Manitoba. Other breeding areas include Alaska, Yukon, Northwest Territories, and the pothole region of southern Canada and the northern United States.

Pacific Coast - Canvasbacks migrate along the Pacific Coast to and from their northern breeding areas. They are found in most of the major estuaries along the lower west coast during winter, including Puget Sound, Willapa Bay, and Humboldt Bay with the largest populations found in the San Francisco Bay.

San Francisco Bay - Within the San Francisco Bay Estuary, canvasbacks comprise 7% of the waterfowl, and 46.5% (1989) to 54% (1990) of the mid-winter population in the Pacific Flyway (USFWS unpubl. data summarized in Accurso 1992). Many birds also stage on the Estuary during migration (Cogswell 1977).

Suisun - About 13-16% of canvasbacks in the Estuary occur in Suisun with peak numbers of greater than 6,000 canvasbacks (Accurso 1992). Eighty percent of the waterfowl in open water habitats were found in Suisun Bay proper rather than Honker Bay or Carquinez Straight (Suisun managed marshes were not included in this survey; **Figure 6.7**).

North Bay - Between 38-59% of canvasbacks wintering in the Estuary in 1988-1990 were found in the northern salt evaporation ponds (Accurso 1992). The greatest number of canvasbacks in the Estuary are found in these ponds. An additional 9.5-25.5% of canvasbacks are found in the open bay area (**Figure 6.7**).

Central Bay - Only 1% of canvasbacks are found in the Central Bay; however, hundreds have been reported in Lake Merritt adjacent to the Bay (Cogswell 1977; **Figure 6.7**).

South Bay - Up to 17% of wintering canvasbacks are found in South Bay salt evaporation ponds with an additional 1.7-1.9% in the open bay. Up to 4-5% of waterfowl in the salt evaporation ponds (peak 6,400) are canvasbacks. Canvasbacks are the third most abundant duck found in this region (**Figure 6.7**).

Historical Information

Historically, canvasbacks were likely very abundant in parts of the Estuary. Areas mapped by Jose Canizares in 1776 in the northern reach of the Estuary were labeled "Forests of the red duck" (Josselyn 1983). Canvasbacks also were described as "abundant" in San Francisco bays and marshes in the winter in the early 1900s (Grinnell and Wythe 1927), arriving in early October and departing in early April, while peaking from late November to early March. They historically used open, deeper water for roosting, foraging in inner bays and marshes closer to shore (Grinnell and Wythe 1927). Christmas Bird Counts (National Audubon Society, unpubl. data) from Palo Alto and San Jose show a population decline of 0.27% and 1.13%, respectively, from 1969 to 1996 on the basis of the small areas surveyed. The regional population of canvasbacks actually decreased by 50% from the 1970s to the mid-1980s according to annual mid-winter surveys (USFWS, unpubl. data).

Population Trends

National - The continental canvasback population averages 534,000 birds but declined between 1955 and 1993 (Hohman et al. 1995). The population is highly skewed with only 20-30% females (Trauger 1974) or 1.94 males per each female in spring (Bellrose et al. 1961) and suggests an older age structure. Females have 27% higher mortality (Geis 1959). With about 30% females, the breeding population is estimated as 140,000 pairs. There are an estimated 1.03 young per adult during the fall flight (Bellrose 1980). Adult mortality is 52%, while juvenile mortality is about 77% (Geis 1959).

Regional - In the 1950s, 79% of the wintering canvasbacks were found in the Atlantic or Pacific flyways. However, by the 1990s, 44% of the birds were found in the Central and Mississippi flyways. A large increase was also noted in Mexico. Annual survival was found to be higher in the Pacific versus the Atlantic Flyway populations (female 56-69%, male 70-82%) (Nichols and Haramis 1980). Although the overall population estimate is 2.0-2.5 males per female, the sex ratio varies from 2.9-3.2 in the Atlantic Flyway, to 1.6-1.8 in the Mississippi (Woolington 1993), to 2.2 in the Pacific (Hohman et al. 1995).

Local - San Francisco Bay remains one of the top ten major wintering areas for canvasbacks in North America. The San Pablo Bay National Wildlife Refuge

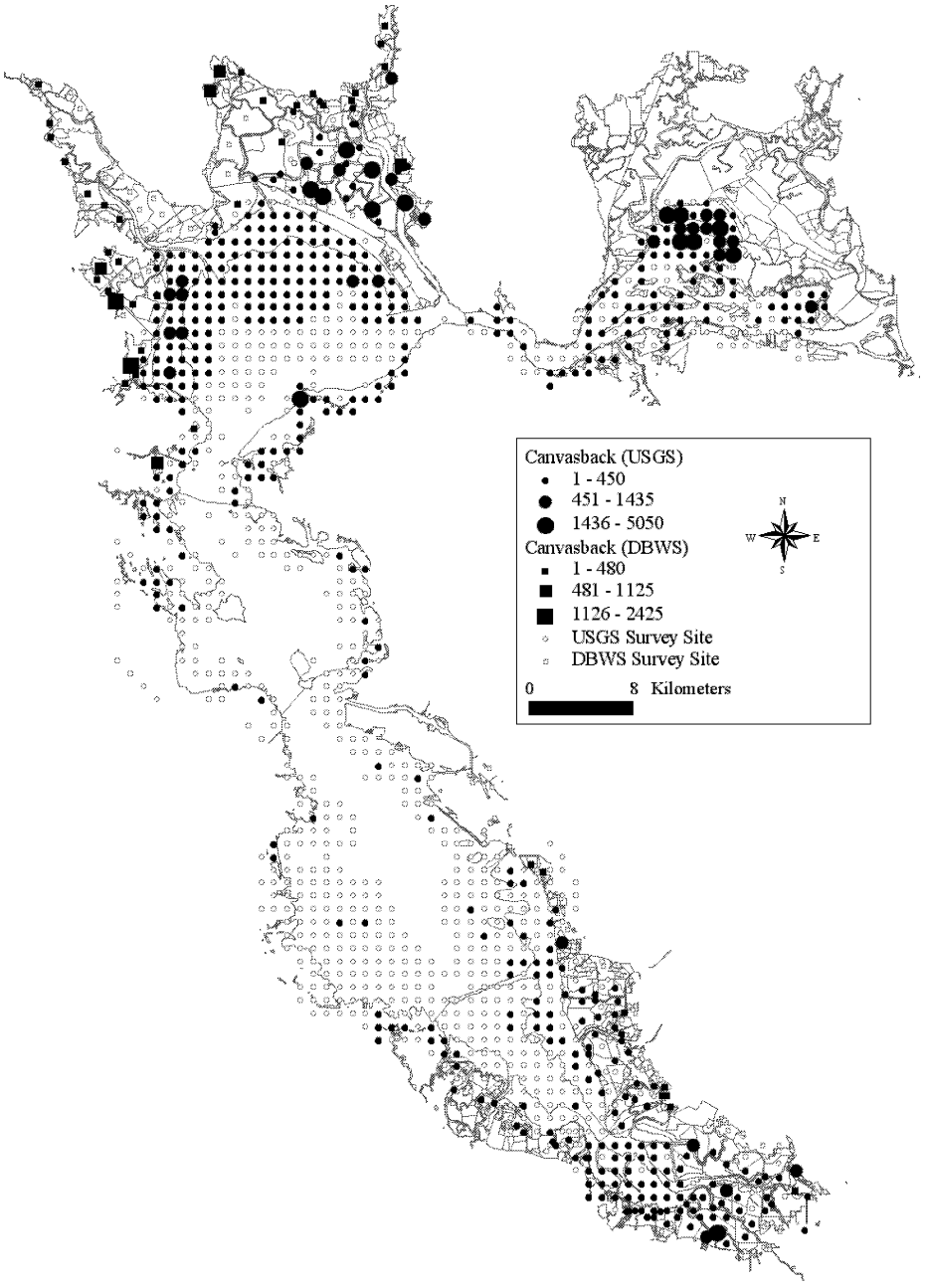


Figure 6.7 Maximum Counts of Canvasback

Open water data from the USGS Study of Waterfowl in Open Bays and Salt Ponds, 1988-1990 (USGS, unpubl.), John Takekawa (unpubl. data), and Accurso 1992.

Bayland data from the Diked Baylands Wildlife Study (DBWS),1982-1989 (USFWS, *in prep*.).

was established for protection of this species. Canvasbacks are the fifth most numerous diving duck in winter in the Estuary (Accurso 1992) and account for 6-7% of all waterfowl. Their peak numbers are observed in early to mid-January. Population numbers have decreased from 60,000 canvasbacks in the 1960s to about 25,000 birds in the early 1990s.

Habitat Use and Behavior

Unlike most ducks, canvasbacks are dependent on aquatic habitat throughout their life cycle including the breeding period (Hohman et al. 1995). They are found in estuarine and lacustrine habitats throughout California (Zeiner et al. 1990). They are benthivores that feed in shallow waters over and near intertidal mudflats (Cogswell 1977). They prefer shallow depths with 80% of canvasbacks recorded in areas of less than 3 meters depth and 60% in areas less than 2 m depth (Accurso 1992). Their use of shallow areas of <0.99 m was twice the proportion of the availability of those areas. Canvasbacks use salt evaporation ponds of low (20-33 ppt) or medium (34-63 ppt) salinity in medium-sized ponds (2-2.25 km^2). They generally roost in open water areas.

Foraging - Canvasbacks are strongly associated with foraging on aquatic plants, including wild celery (*Vallisneria americana*) with which it shares a similar scientific name. Early diet studies suggested canvasbacks foraged mostly on plants (80%) with some animal (20%) prey (Cottam 1939, Palmer 1975); food items included

wild celery, sago, bulrush seeds, and mollusks. In Chesapeake Bay, when wild celery, widgeon grass, eelgrass, and sago (Stewart 1962) decreased due to turbidity, nutrient enrichment, sedimentation, and salinity changes, canvasbacks switched diets to mollusks primarily (Perry and Uhler 1988). Birds on Humboldt Bay were found to consume sago pondweed, widgeon grass, and clams (Yocom and Keller 1961). Invertebrates are now their principal foods in winter (Zeiner et al. 1990). Canvasbacks in San Francisco Bay fed predominantly on 88% (South Bay) and 98% (North Bay) mollusks by volume (CDFG, unpubl. rept.). Canvasbacks may have to forage longer and consume greater quantities of clams to obtain the nutritive values obtained from aquatic plants such as wild celery (D. Jorde and M. Haramis, pers. comm.). They have a crepuscular feeding pattern (Zeiner et al. 1990).

Roosting - Canvasbacks generally roost on open water areas. They are found in larger salt evaporation ponds.

Movement - No information.

Conservation And Management

Canvasbacks are the least abundant, widely distributed game duck. They have had special hunting protection during several periods including 1936-37, 1955-74 and the present time (Anderson 1989). The goal for the continental population established by the North American Waterfowl Management Plan is 540,000 (USFWS and CWS 1994).

Contaminant Risks - Studies conducted on contaminants in canvasbacks (Miles and Ohlendorf 1995, Ohlendorf et al. 1986) indicate elevated tissue concentrations in the Estuary. Recent invasions of the Asian clam (*Potamocorbula amurensis*) indicate an exponential increase in this exotic species which may triple the concentration of selenium (Luoma and Linville 1995) in prey likely to be consumed by canvasbacks.

Disturbance - Canvasbacks may be disturbed by boats, aircraft, people, and pets. They may avoid preferred foraging areas during the day but may use these areas at night. They will use undisturbed open water roosting areas near feeding sites when available.

Recommendations

San Francisco Bay is one of the three largest wintering areas for canvasbacks in North America. The San Pablo Bay National Wildlife Refuge was established to protect canvasbacks. Canvasback numbers in the Estuary have decreased substantially over the past 20 years to about 20,000 birds. This trend may be reversed by supporting more shallow, open water habitats (<2 m in depth) with dense mollusk populations and undisturbed roosts, particularly in the North Bay and Suisun, where they have historically been most abundant. This habitat type is also crucial to scaup, which are declining continentally.

Regionally, the most important areas for canvasback are North Bay and Suisun, although the other regions provide significant support as well. Important habitat elements to consider for canvasbacks include tidal channels; bottom; open water; mudflat; eelgrass; perennial pond; and mouths of rivers, creeks, and sloughs. Ideal pond size appears to be 1.75 - 2.25 km^2. Undisturbed roost sites should be at or within 2 km of foraging areas. Marshes managed for canvasback should have shallow (<2 m) open water. Salt ponds (used for feeding and roosting) managed for canvasback should have low salinity, between 34 ppt and 64 ppt.

Habitat goals for the region include increasing the current acreage of lagoons (with >2.25 km^2 undisturbed resting area), managed marsh, treatment ponds (with depths managed for birds), low-salinity salt ponds, and tidal reach (valuable foraging area). The current acreage of intertidal flat and shallow bay or strait is unlikely to increase, but should be maintained as feeding areas.

Suisun - The shallows of northern Suisun Bay are critical for support of canvasbacks. Other areas of importance within the Suisun subregion include the middle of Honker Bay, the shallows north of the shipping channel, and Benicia State Park. The shallows in northern Suisun Bay show high use, with counts of a few thousand birds. The middle of Honker Bay is moderately used by thousands of birds. The shallow water north of the shipping channel and the area around Benicia State Park are both moderately used by hundreds of birds. To achieve the recommended increase of the subregional population, there must be an increase in the area of large brackish shallow water. Habitat goals for the Suisun subregion include maintaining the current acreage of managed marsh, shallow bay and strait, and intertidal flat, and increasing the current acreages of lagoon, treatment pond, and tidal reach.

North Bay - Canvasbacks are most abundant in the North Bay subregion. Ponds 1AN and 1N are used by thousands of birds, and Ponds 3N, 4N, 5N are used by many thousands of birds. White Slough is also heavily used (many thousands of birds), and the marsh near Slaughterhouse Point is moderately used by thousands of birds. Birds also use the Point Pinole area by the many thousands. The mudflats near China Camp and Hamilton Air Field are moderately used by thousands of birds. We recommend restoring this subregional population by increasing large brackish shallow water areas. If Ponds 3-5 of the salt ponds are altered, suitable alternative habitats must be provided or the population may decrease substantially.

Habitat goals for the North Bay subregion include maintaining the current acreage of intertidal flat and

shallow bays or straits, and increasing areas of lagoons, managed marsh, low salinity salt pond, treatment pond, and tidal reach.

Central Bay - The Berkeley Marina and Emeryville Crescent are both lightly used by a few hundred birds. Point Isabel and the Albany mudflats are used by a few hundred birds. Richardson Bay, Candlestick Point, and the shallows around the Oakland Airport also are used by hundreds of birds. To increase the limited population, increase large brackish shallow water areas. Habitat goals for the Central Bay subregion include maintaining the current acreage of intertidal flat and shallow bays or straits, and increasing areas of lagoon, managed marsh, low salinity salt pond, treatment pond, and tidal reach.

South Bay - Most bayside salt ponds are used by thousands of birds. Some ponds are used very heavily by many thousands of birds. Deep open water habitat is not used. The areas of Mowry Slough and Coyote Creek also receive moderate use by thousands of birds. We recommend maintaining the subregional population. An increase of large, shallow (<6 ft.), low salinity (less than 33 ppt) water areas would be beneficial. If salt ponds are altered, suitable alternative habitat must be provided.

Habitat goals for the South Bay subregion include maintaining the current acreage of intertidal flat and shallow bays or straits, and increasing areas of lagoon, managed marsh, low salinity salt pond, treatment pond, and tidal reach.

Research Needs

Information is needed on region-specific population relationships, diet effects, and cross-seasonal studies of diet and contaminants in their life cycle.

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Surf Scoter

Melanitta perspicillata

A. Keith Miles

Introduction

Surf scoters are the least studied of the North American waterfowl (Johnsgard 1975, Palmer 1976). San Francisco Bay appears to be the most important inshore habitat in the eastern Pacific, south of the Straits of Georgia and Puget Sound (Martell and Palmisano 1994, Small 1994). This species is representative of sea ducks that primarily use deeper, open water habitat. Associated species are white-winged scoters (*M. fusca*), black scoters (*M. nigra*), and red-breasted mergansers (*Mergus serrator*).

Description

Scoters are Anatid sea ducks of the Tribe Mergini. The surf scoter is the most common of the three North American scoters that winter at San Francisco Bay (Bellrose 1980). Adult surf scoters measure about 43 - 53 cm in length with a wing span of 76 - 86 cm, and weigh 0.7 - 1.1 kg. Adults are nearly identical in size to black scoters and slightly smaller than white-winged scoters. Male surf scoters have a distinctive hump on the bill. The coloration of all three scoters is also similar; the distinct difference is that adult male surf scoters have a white patch on the crown and nape. However, first-year males are all black and very similar in appearance to black scoters. Female and immature surf scoters have a dusky brown coloration, similar to white-winged scoters (except the latter have distinct patches of white on the wings). Surf scoters rarely vocalize, but do emit a low, guttural sound. The distinct whistling sound during flight is generated by air passing over their wings.

Breeding Biology - Scoters prefer fresh water, shallow, rocky, Arctic lakes for breeding. The breeding chronology begins with egg-laying in early June, and hatching the second or third week of July (Savard and Lamothe 1991). Nests are built away from water on the ground, and consist of a shallow excavation lined with

Courtesy USGS/NBS

grasses and feathers. Egg clutch and brood size are unclear because of the few observations made. Those observations have indicated clutches of about five eggs, and broods of about five young, but brood amalgamation appeared common.

Migration Ecology - Surf scoters migrate directly to the oceanic coasts from the breeding areas. Three times more birds migrate to the Pacific Coast than to the Atlantic Coast. Their subsequent southward migratory destination appears conditioned to the preferred stopover and wintering destination of individual flocks.

Wintering Ecology - Surf scoters use both offshore and inshore marine and estuarine habitats during winter. Marine habitat encompasses the entire Pacific Coast from the Aleutian Islands, Alaska to central Baja California, Mexico (Root 1988). The Canadian inside passage appears crucial as habitat. Surf scoters are common along the California coast from October to May, and San Francisco Bay appears to be the most important inshore habitat in the eastern Pacific, south of the Straits of Georgia and Puget Sound (Martell and Palmisano 1994, Small 1994).

Distribution and Abundance

North America - The breeding range of surf scoters extends from patchy sites in western Alaska, extensive occupation across the Northwest Territories to Hudson Bay, and east of the Bay into Labrador (Bellrose 1980). The wintering range extends from the Aleutian Islands to Baja California on the west coast, and from the Bay of Fundy to Florida on the east coast. They also occur on the Great Lakes and on inland bodies of water along the coastal states, but are most common either on nearshore marine waters or calm estuaries. Bellrose (1980) estimated wintering populations of surf scoters in North America at about 130,000 birds.

Pacific Coast - The wintering range extends from the Aleutian Islands to Baja California on the Pacific Coast.

San Francisco Bay - Most counts of scoters lump the three species together. Surf scoters comprise the majority of scoters observed on San Francisco Bay. Accurso (1992) identified scoters as the second most abundant waterfowl on San Francisco Bay in two wintering seasons between 1988 and 1990, accounting for about 20% of the waterfowl counted. Scoters are common throughout the open waters of San Francisco Bay. Scoters can be observed close to land near China Camp and Hamilton Airfield; near shore at the Presidio cliffs, and off Point Molate in the Central Bay; and near shore on open waters off Coyote Hills, the Edwards National Wildlife Refuge fishing pier, the bayshore levee at Foster City, and the San Mateo County NWR Fishing Pier (pers. obs.; Sequoia Audubon Society 1985).

Suisun - Flocks numbering in the high hundreds were found on the open waters of Suisun Bay in early December. Scoter numbers increased to the upper hundreds and low thousands (<10,000) later in the winter, with their distribution shifting from north to south Suisun Bay, and east to Chipps Island and Honker Bay (**Figure 6.8**). Also, scoter numbers ranged from the low hundreds to low thousands (<10,000) in the Carquinez Straits region east of Suisun as the winter season progressed.

North Bay - Beginning in mid-October, scoters were common throughout north San Francisco Bay, with the larger flocks (numbering in the mid- to upper hundreds) common near the Hamilton Airfield (Accurso 1992). By mid- to late winter, scoters were widespread in the North Bay with some flocks numbering in the thousands (**Figure 6.8**).

Central Bay - Scoters have been identified as the most abundant waterfowl in this region (Accurso 1992). Peak numbers of about 24,000 to 30,000 have been counted on the open waters of the Central Bay in the early wintering season (**Figure 6.8**).

South Bay - As the second most abundant waterfowl in this region, numbers of scoters were highest in December (about 9,500 - 11,000) in the two winters between 1989 and 1990 on the open waters in this region (Accurso 1992; **Figure 6.8**).

Historical Information

No information.

Population Trends

Mid-winter surveys (conducted in January) of scoters indicated a high of about 72,000 scoters on San Francisco Bay in 1991, and a low of 1,200 birds in 1996 (Trost 1997). Their numbers rebounded to about 28,000 in 1997. Mid-winter surveys of the western states and Mexico indicated about 69,500 scoters, which was about 20% lower than the ten year average (1987 - 1996).

Habitat Use and Behavior

Foraging - Surf scoters are strong divers, and have been observed foraging in the 2-10 m depth range (pers obs., Sequoia Audubon Society 1985, Root 1988). Scoters feed in the open waters of the Bay, and also along the cliffs at the entrance to San Francisco Bay. Their habit is to dive in the areas on the trailing side of waves breaking at the cliffs (Sequoia Audubon Society 1985). They have also been observed feeding on rock-bound intertidal or shallow subtidal mussels or scallops at high tide. Their preferred diet consists of clams inhabiting silty or sandy substrate, or mussels attached to hard substrata such as pilings or rocks (Vermeer and Bourne 1982), but are likely to opportunistically consume other molluscs and also crustaceans.

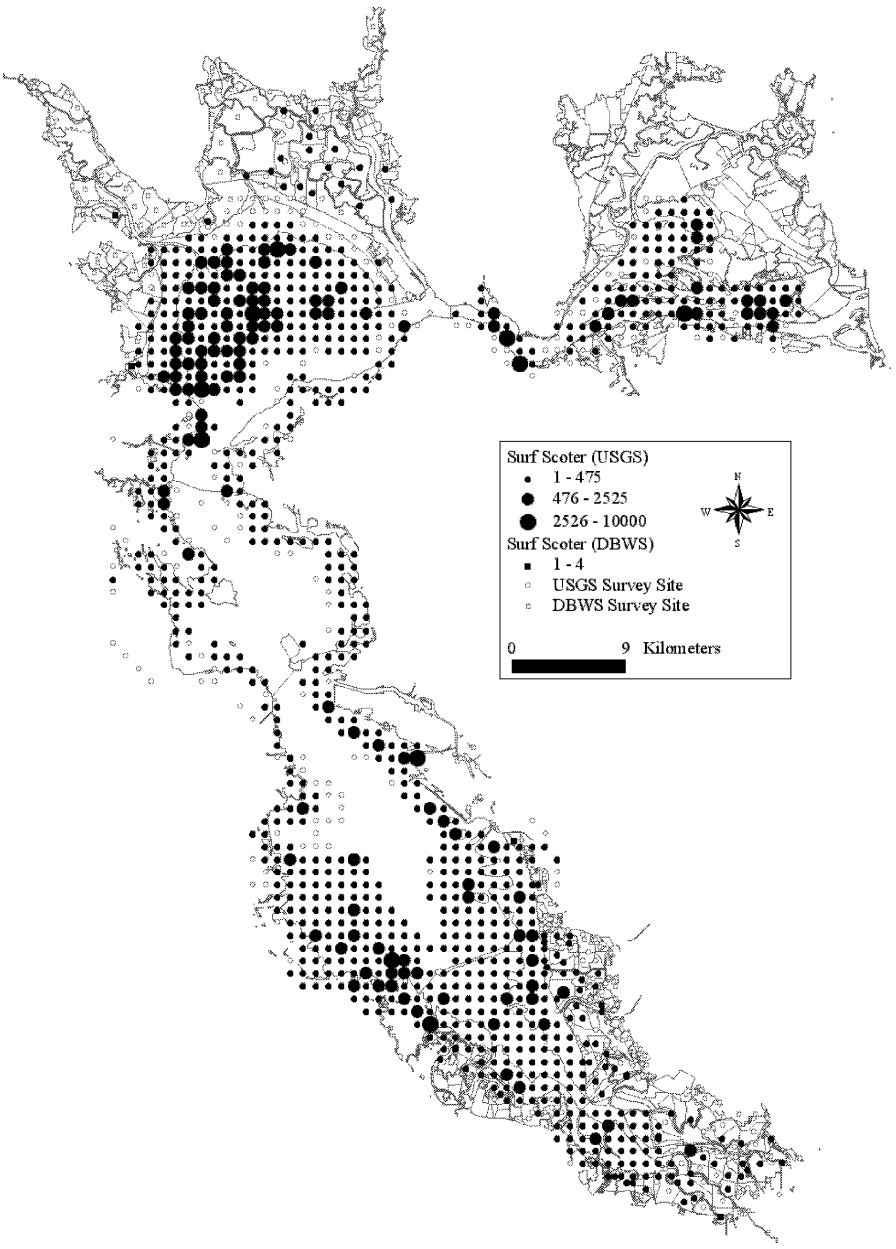

Figure 6.8 Maximum Counts of Surf Scoter

Open water data from the USGS Study of Waterfowl in Open Bays and Salt Ponds, 1988-1990 (USGS, unpubl.), John Takekawa (unpubl. data), and Accurso 1992.

Bayland data from the Diked Baylands Wildlife Study (DBWS),1982-1989 (USFWS, *in prep.*).

Roosting - Surf scoters roost almost exclusively on open, coastal bay, or lake waters.

Movement - Movement seems related to foraging, roosting, or disturbance. Like most diving waterfowl, surf scoters probably conduct short-distance moves from area to area as prey are depleted. Flocks have been observed at the Bay riding the high tide to shore to feed on blue mussels along the rocky shore or ribbed mussels in the cordgrass habitat.

Conservation and Management

Contaminant Risks - Several studies have indicated elevated concentrations of elemental contaminants in scoters inhabiting San Francisco Bay (e.g., Ohlendorf and Fleming 1988; CDFG, unpubl.). The consequences of elevated selenium or mercury to survival or productivity of these scoters have not been determined.

Disturbance - Surf scoters appear very intolerant of human disturbance, particularly motorboats. Their foraging movement into the intertidal zones at high tide occurs at areas secluded from human disturbance or at night. Overflights by birds of prey also were observed to elicit panic response by flocks roosting on open water. Incidental mortality of scoters was recorded from commercial fishing with gill nets (Heneman 1983). However, regulations curtailing coastal gill net fishing have probably reduced the number of birds killed to those caught in nets accidentally set adrift.

Recommendations

The important habitats used by scoters are the open waters throughout San Francisco Bay, and the underlying sediments for foraging. Scoters will forage in low tidal wetlands during high tide. Scoters are susceptible to bioaccumulation of contaminants. Restoration of the Bay's shorelines to tidal wetlands should include studies of the potential for mobilization of contaminants that may be sequestered in existing soils or sediments.

Scoters primarily use the open coast. San Francisco Bay appears to be important to populations of scoters that may either be historically affiliated with the Bay or that seek refuge in the Bay during inclement weather on the coast. The Bay (all subregions) provides very crucial wintering habitat for these birds. Besides open water, other important habitat elements include clay-silt substrate, sand substrate, and rock substrate. The primary recommendation to support scoters is to maintain the current acreages of shallow bay, intertidal flat, and low tidal marsh.

Suisun - Maintain current acreages of shallow bay, intertidal flat, and low tidal marsh.

North Bay - All open waters of the North Bay are used by scoters, and particularly important are the open waters of of China Camp and Hamilton Airfield (for foraging and wind protection), and the deeper water off of Wilson Point. Maintain current acreages of shallow bay, intertidal flat, and low tidal marsh.

Central Bay - All open waters near the shoreline in the Central Bay are used by scoters. The feeding habitat near the shore at the mouth of the Bay is particularly important, and eelgrass beds sporadically distributed in Central Bay may be important. Maintain current acreages of shallow bay, intertidal flat, and low tidal marsh.

South Bay - Open waters throughout the South Bay are important for scoters. Of particular importanne are the open waters off of the Coyote Hills area and south of Coyote Hills, and the open waters near Foster City. Maintain current acreages of shallow bay, intertidal flat, and low tidal marsh.

Research Needs

Surf scoters are the least studied of the North American waterfowl (Johnsgard 1975, Palmer 1976), but recent die-offs in Alaska has raised concern about these ducks (Bartonek 1993). Elevated concentrations of contaminants have been detected in scoters, particularly in the Suisun region. Inhabitants of this region should be radio-tagged in order to determine their wintering movements and survival, and also their survival and productivity on the breeding grounds as compared to other sub-populations of scoters.

Acknowledgments

Special thanks to Janice Alexander (Biological Resources Division) for compiling and synthesizing data and maps on waterfowl distribution at San Francisco Bay, and thanks also to Bob Trost, U.S. Fish and Wildlife Service, and Mike Casazza and Mike Miller, Biological Resources Division, U.S. Geological Survey.

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Ruddy Duck

Oxyura jamaicensis

A. Keith Miles

Introduction

This diving duck is widespread and has one of the largest wintering concentrations in the San Francisco Bay Estuary. It uses a variety of open wetlands, including managed marsh areas, but prefers salt ponds found around the perimeter of San Francisco Bay. It is grouped with the bufflehead (*Bucephala albeola*), which uses similar habitat.

Description

These ducks, also known as "stifftails," are Anatid ducks of the Tribe Oxyurini. Adult ruddy ducks are small but full-bodied, measuring about 37 - 41 cm in length, with a wing span of 53 - 61 cm, and weigh 0.3 - 0.7 kg (Bellrose 1980). The ruddy duck's stiff, erect tail is its most pronounced attribute. During breeding season, adult males display a reddish-brown coloration, white throat patch, and exceptionally bright blue bills; both sexes have white cheek patches. Otherwise, males and females are the same dull brown color, except that males maintain a bright white cheek patch.

Courtesy USGS/NBS

Breeding Biology - Suitable breeding habitat consists of stable, fresh or alkaline water that supports emergent vegetation (Johnsgard and Carbonell 1996). Nests are characteristically placed deep into reedbeds with channels or easy access to open water; ruddy ducks will use nest boxes placed in the reeds. Breeding birds apparently require about 0.5 to 1.5 sq. km each, but in some places the density of nests averages one every 0.6 hectares. Males do not defend territories, but will guard an area of about 3 m around a female. Unique male courtship displays consist of "rushing" (swimming or half-swimming, half-flying in hunched position) the female, and "bubbling" (beating the bill rapidly against the breast). Courtship occurs from January into July. Pair bonding is considered loose, lasting only from just before to just after egg-laying. Egg-laying occurs from early April to late August. Ruddy ducks are known to parasitize other nests. Clutch size averages about seven eggs; incubation and rearing both average about 25 days each (Gray 1980).

Migration Ecology - Long-distance migratory behavior of ruddy ducks is not well-defined. Substantial variations have been recorded for size of migrant flocks, and it is suspected that migration at night is common (Bellrose 1980). Ruddy ducks sometimes migrate in flocks with other species of waterfowl. The best known migration route to eastern wintering areas is from the northern prairie wetlands to the Chesapeake Bay region. Migration corridors for western populations were suggested to extend from western Canada to Utah to California, and from Utah or California to the west coast of Mexico. Fall migration occurs from about mid-September into December; spring migration occurs from about February through April.

Wintering Ecology - More than half of the ruddy ducks in North America winter at or near the Pacific Coast from southern Canada to Mexico. The majority (85%) of these winter in California, primarily at San Francisco Bay. Coastal wintering areas consist of shallow-depth lagoons or estuaries. Protected or managed wetland areas around San Francisco Bay (particularly salt ponds in the South and North bays) and elsewhere in California are crucial to inland wintering populations (Root 1988).

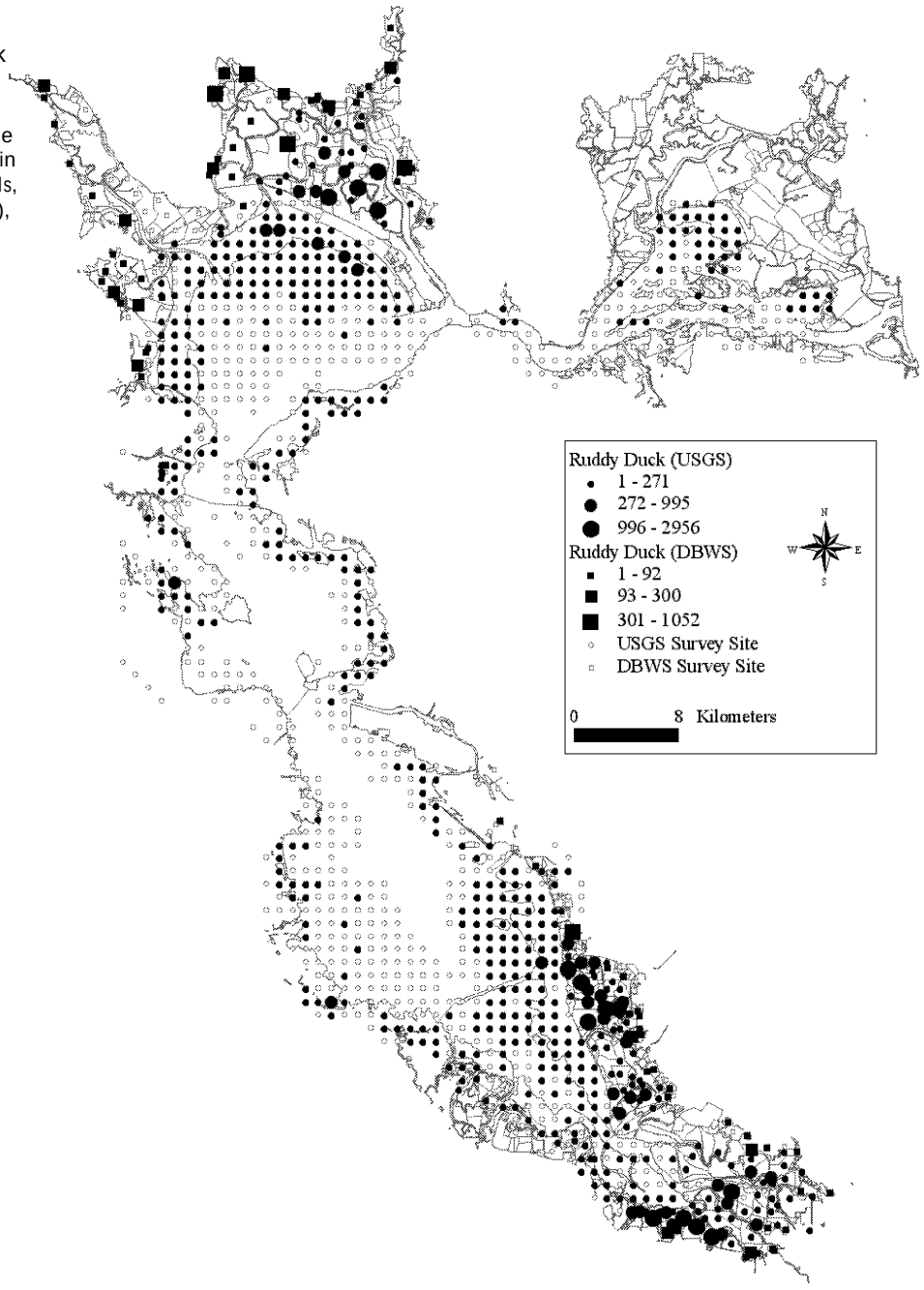
Distribution and Abundance

North America - The breeding range of ruddy ducks extends from central British Columbia east to southern Manitoba and Minnesota, south from the western portion of the central states throughout the western states. Second to the Pacific Coast, the wintering range along the Atlantic Coast is mainly Chesapeake Bay (estimated 40,000 birds), with smaller groups further south; ruddy ducks that winter along the Gulf Coast States of the U.S. are estimated at 20,000 (Johnsgard and Carbonell 1996). Current

Figure 6.9 Maximum Counts of Ruddy Duck

Open water data from the USGS Study of Waterfowl in Open Bays and Salt Ponds, 1988-1990 (USGS, unpubl.), John Takekawa (unpubl. data), and Accurso 1992.

Bayland data from the Diked Baylands Wildlife Study (DBWS),1982-1989 (USFWS, *in prep*.).



wintering populations for North America are estimated at about 180,000.

Pacific Coast - About 85% of the estimated 122,000 (Trost 1997) ruddy ducks that migrated to the west coast of North America stayed in California in winter 1997. According to Bellrose (1980) the primary wintering areas are San Francisco Bay, Imperial and San Joaquin valleys, and southern California coastal bays. The remaining ruddy ducks migrate to the west coast of Mexico.

San Francisco Bay - The greater number of ruddy ducks that migrate to California overwinter at San Francisco Bay. Since 1986, based on mid-winter surveys, numbers have ranged from about 1,900 (1996) to 28,300 (1991) (Trost 1997). In 1997, surveys indicated about 6,200 ruddy ducks on the Bay.

Suisun - Ruddy ducks infrequently inhabit Suisun, and primarily have been observed as individuals on managed marshes or stop-over migrants on open waters (**Figure 6.9**).

North Bay - Salt ponds in the northern Bay support the second highest numbers of ruddy ducks in the San Francisco Bay region, with counts from about 1,500 to 10,000 ducks in the two winter seasons between 1988 and 1990 (Accurso 1992). Smaller flocks numbering in the hundreds were observed in the near shore, northern-most, and northwestern waters of the Bay (**Figure 6.9**).

Central Bay - Observations of ruddy ducks were usually limited to individuals in the near shore waters, or small flocks numbering fewer than 100; however, larger flocks numbering several hundred birds were observed in Richardson Bay on the west side of the Central Bay in mid-November to early December, indicating this area is probably an important stop-over for migrating ducks (Accurso 1992; **Figure 6.9**).

South Bay - Salt ponds located on the eastern and southern shores of the South Bay have supported the greatest numbers of ruddy ducks in the Bay region. These ducks numbered from about 1,300 to 19,000 ducks during the two winters between 1988 and 1990 (Accurso 1992). Smaller flocks numbering in the hundreds were observed in the near shore waters of the South Bay adjacent to the salt ponds (**Figure 6.9**).

Historical Information

No information.

Population Trends

Ruddy duck populations increased about 12 percent in North America between 1965 and 1992 (Trost 1997). The 1997 mid-winter survey that indicated about 122,000 ruddy ducks wintering in the western states and Mexico was 42 % above the 10 year average of surveys from 1987 to 1996 (Trost 1997).

Habitat Use and Behavior

Foraging - Ruddy ducks dive about 1-3 m for their food. They apparently prefer submerged aquatic vegetation, e.g., wigeon-grass or pondweed, but consume more benthic invertebrates during the summer or when vegetation is less available (Tome 1991). Their vegetative preference may be overestimated because soft-bodied insects, mollusks, or crustaceans are indiscernible in gizzards commonly used to determine food habits (Johnsgard and Carbonell 1996). Esophageal contents in ruddy ducks collected at Chesapeake Bay were mostly amphipods and other benthic invertebrates (Tome and Miles, unpubl. data). Ruddy ducks are known to feed both diurnally and nocturnally (Tome 1991). Ruddy ducks observed foraging at the salt ponds and northern and southern San Francisco Bay probably are feeding mostly on invertebrates.

Roosting - Ruddy ducks roost almost exclusively on open waters of protected estuaries, lakes, or ponds. They are most often observed roosting on salt ponds at the northern and southern regions of San Francisco Bay.

Movement - Personal observations of ruddy ducks at Chesapeake Bay indicate local flock movements between roosting and feeding areas, and we suspected that movements occurred more commonly at night. Similar habits may occur at San Francisco Bay with these ducks moving primarily between salt ponds and nearby Bay waters.

Conservation and Management

Contaminant Risks - On the east coast, ruddy ducks have characteristically been observed wintering in heavily urbanized embayments (e.g., Baltimore Harbor), with no apparent detriment to population numbers (Tome and Miles, unpubl. data). However, when other waterfowl are considered as surrogates, then inorganic elements, such as lead, mercury, or selenium, can be toxic at low concentrations.

Disturbance - Ruddy ducks are intolerant of human presence. However, they seem tolerant of urbanization, i.e., presence of nearby roadways or highways, and moderate levels of pollution. The presence of avian predators elicit flock dispersal and flight.

Recommendations

Any efforts to restore altered wetlands to historically tidal wetlands in the San Francisco Bay region should consider the importance of human-created water impoundments, e.g., salt ponds, to wintering waterfowl populations. San Francisco Bay is the most important wintering estuary for aquatic birds on North America's Pacific Coast. The efforts of the U.S. and Canadian governments in concert with private foundations, such as Ducks Unlimited and the Nature Conservancy, have contributed to the increase in numbers of ruddy ducks and other waterfowl through the acquisition and preservation of breeding habitat. Ruddy duck populations have become dependent on San Francisco Bay's altered habitats for winter-season survival. Intensive studies must be conducted to determine the effects of tidal wetland restorations on avian populations dependent on altered habitats.

The salt ponds of the North Bay are currently the most important area for ruddy ducks, and low salinity salt ponds provide crucial wintering habitat. Other habitat types and areas are used more as migratory stop-over points, while salt ponds are the preferred, crucial habitat. Important habitat elements are clay-silt substrate and sand substrate. Regional goals to support this species would include increasing the current acreage of low salinity salt ponds, and maintaining the current acreages of tidal reach and lagoon.

Suisun - Suisun is currently little used by ruddy ducks, but an increase in the amount of low salinity salt pond may increase bird numbers in this subregion. Population is sparse and widespread in the managed marsh. Important areas include open waters (migratory stop-over) and managed marsh. Goals to support ruddy duck include maintaining the current acreages of managed marsh, tidal reach, and lagoon.

North Bay - The low salinity salt ponds are the single most important habitat for wintering ruddy ducks in the North Bay. These salt ponds supported 25 to 30% of the populations of ruddy ducks that overwintered at San Francisco Bay between 1988 and 1990 (Accurso 1992). Particularly important are Ponds 3N, 6N, 1N, 2N, 4N, 5N, 2AN, 7N, and 1AN. The first six of these ponds were crucial habitat for about 90% of the maximum counts of ruddy ducks monitored in the North Bay in 1988-1990 (Accurso 1992). The nine ponds represent 90% of the habitat (by hectares) used by ruddy ducks, and should be maintained along with the remaining ponds in the North Bay because of currently increasing numbers of these ducks. Goals to support ruddy ducks include maintaining the current acreages of tidal reach and lagoon, and increasing the amount of low salinity salt pond.

Central Bay - Ruddy ducks generally use only open water habitat in the Central Bay. Increasing the amount of low salinity salt ponds in this very urbanized subregion does not seem feasible, though this may increase the subregional population. Richardson Bay appears crucial for stop-over migrants. Goals to support ruddy duck include maintaining the current acreage of tidal reach and lagoon.

South Bay - Low salinity salt ponds are crucial wintering habitat for ruddy ducks in the South Bay region. Populations of ruddy ducks inhabiting the Bay probably are increasing (Trost 1997), and the maintenance of these salt ponds is crucial. Of particular importance are Ponds A1, A2E, A2W, A3N, A3W, A4, A9, A10, A12, A14, A18, AB1, AB2, B1, B2, B3C, B4, B5, B6, B6A, B6C, B7, B8, B8A, B9, B10, B11, B12, B13, B14, M1, M3, M4, N1, N2, N3, N3A, N4, R2, and R3. Of these, 20 ponds supported 90% of the ruddy ducks wintering in south San Francisco Bay between 1988 and 1990 (Accurso 1992). Overall, South Bay salt ponds supported from 55 to 67% of the ruddy ducks wintering at San Francisco Bay during this time period. Groups of ruddy ducks numbering from 6 to 174 ducks were observed on 39 other ponds, which are probably important for localized movements of ducks inhabiting the South Bay. Goals to support ruddy ducks in the South Bay include maintaining the current acreages of low salinity salt ponds, tidal reaches, and lagoons.

Research Needs

Any plans for habitat alteration, including the restoration of salt ponds to tidal wetlands, have to consider the potential impact on the distribution and habitat use by ruddy ducks. Studies are recommended to determine importance of salt ponds for abundance of waterfowl prey in comparison to natural ponds, and the effects of salt pond alterations on ruddy duck distribution, abundance, survival, and behavioral modification. The potential for overcrowding by waterfowl and subsequent increase in avian disease outbreaks that might result from any reduction in salt pond habitat also needs study.

Acknowledgments

Special thanks to Janice Alexander (Biological Resources Division) for compiling and synthesizing data and maps on waterfowl distribution at San Francisco Bay, and thanks also to Bob Trost, U.S. Fish & Wildlife Service, and Mike Casazza and Mike Miller, Biological Resources Division, U.S. Geological Survey.

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Western Snowy Plover

Charadrius alexandrinus

Gary W. Page
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Introduction

The population of snowy plovers that breeds along the Pacific Coast of the United States and Baja California, Mexico was designated as Threatened by the U.S. Fish and Wildlife Service in March 1993. The Pacific Coast population has declined most likely due to habitat loss and degradation, but also suffers from poor nesting success primarily due to predation. Critical habitat for the plover has been identified and a recovery team was formed. Along the Pacific Coast, San Francisco Bay is the northernmost area supporting over 100 breeding snowy plovers (Page et al. 1991). Salt ponds, their levees, and pond edges, which may mimic historic salt pan habitat in some essential way for the plover, provide almost all known snowy plover nesting habitat in San Francisco Bay today. The potential importance of San Francisco Bay salt pond habitat to the persistence and recovery of the Pacific Coast population of snowy plovers should be considered in any comprehensive management plan for San Francisco Bay wetlands.

Description

The snowy plover is a small (15-17 cm long) shorebird, with a light brown back and cap; white underparts; brown to black forehead bar; brown to black lateral breast patches and cheek patches; short black bill; and black legs.

Breeding Biology - In coastal regions, snowy plovers nest on the ground on barren to sparsely-vegetated beaches and dunes, on salt evaporation pond levees and edges, and along lagoon margins. In inland areas, they nest on the shores of alkaline and saline lakes and on river bars. Their nest is a simple scrape in the ground lined with small pebbles, shell fragments, plant debris, mud chips, or other debris. Females incubate the three-egg clutch during most daylight hours and males incubate at night (Warriner et al. 1986). The incubation period averages 27 days with an additional 4-5 days for egg laying on the California coast. Females typically desert the male and brood at hatching. Males raise broods until the young fledge, about 30 days after hatching. If a nest fails, the female typically renests with the same mate, up to five times per season, until a clutch hatches. The most successful females may have up to three broods per season and the most successful males may have up to two.

Courtesy USGS/NBS

Migration Ecology - Along the California Coast, including San Francisco Bay, part of the snowy plover population is resident year round and part is migratory. Birds, which nest along the coast, may migrate north or south for the winter or remain at their nesting site. Most birds which breed at inland locations migrate to the coast for the winter. In winter, birds which breed on the coast and birds which breed inland occur in the same flocks. Migrants begin returning to coastal breeding locations as early as late January or early February, but most migration is from early March to late April. Coastal breeders begin departing for wintering areas in early July and the exodus continues through October.

Wintering Ecology - In winter, snowy plovers are usually found roosting in flocks ranging in size from a few individuals to up to 300 birds. They often sit in footprints or other depressions in the sand. Foraging occurs on sandy beaches, salt evaporation ponds, or tidal flats. Although some individuals defend territories on beaches, most plovers usually forage in flocks.

Distribution and Abundance

North America - The snowy plover breeds along the coast of the Gulf of Mexico, and along the Pacific Coast of the United States and Baja California. Inland, it also breeds in the southern Great Plains, the Great Basin, San Joaquin Valley, and southern desert areas of California. Inland populations (except from San Joaquin Valley and Salton Sea) migrate to the coast for the winter. Current information suggests a breeding population of about 21,000 snowy plovers in the United States (Page et al. 1995).

Pacific Coast - Breeding and wintering occurs from southern Washington to Magdalena Bay, Baja California. Birds breeding in San Francisco Bay are considered part of the coastal breeding population. Currently, an estimated 1,900 snowy plovers breed along the west coast of the United States and at least another 1,900 along the western coast of Baja California (Page et al. 1995).

Suisun - At most, snowy plovers probably occur in Suisun only rarely.

North Bay - Small numbers of snowy plover have been found nesting on North Bay salt ponds, and have been seen in diked, seasonal wetlands (Feeney, pers. comm.).

Central Bay - Plovers nest at Alameda Naval Air Station, and also wintered at Alameda South Shore into the 1980s (Page et al. 1986).

South Bay - Although a few pairs have been found nesting on levees in salt ponds of San Pablo Bay (i.e. two pairs in 1989), the majority of snowy plovers in San Francisco Bay nest in the South Bay in salt evaporation ponds south of the San Mateo Bridge. Surveys of South Bay salt evaporation ponds and adjacent habitats tallied the following numbers of adult snowy plover during the peak of the breeding season: 1978 (351); 1984 (270); 1989 (216); and 1991 (176). The 1991 survey excluded a portion of the Baumberg Tract where 29 adult plovers had been recorded on the 1989 survey. On all surveys, at least 87% of the adult plovers were found on the eastern side of the Bay using Guadalupe Slough as the division line.

Historical Information

There are no records of snowy plover breeding in San Francisco Bay prior to the construction of salt ponds. This species may have bred on natural playas on the inner fringes of salt marsh which existed prior to conversion of South Bay marshes to salt ponds. Snowy plovers have been documented in San Francisco Bay during winter as early as the late 1800s (Page et al. 1986).

Population Trends

The breeding population along the western coast of the United States has declined and the breeding range has become increasingly fragmented during the past century. On surveys in the late 1970s, the species was absent from 33 of 53 California coastal locations with breeding records prior to 1970 and was missing from parts of San Diego, Ventura and Santa Barbara counties, most of Orange County, and all of Los Angeles County (Page and Stenzel 1981). Along the coast of Washington, Oregon and California combined, there was an approximate 20% decline in the size of the breeding population on surveys between the late 1970s and late 1980s (Page et al. 1991). Within San Francisco Bay, the population also appears to have declined as evidenced by the drop from 351 adults on the 1978 survey to 226 (216 in South Bay) on a 1989 survey (Page et al. 1991).

Habitat Use and Behavior

Foraging - Snowy plovers feed in typical plover fashion, usually pausing, looking, then running to seize invertebrate prey from the surface of a beach, tidal flat, or salt pan. Plovers also probe shallowly into the sand or mud for prey, or lower their heads and charge open-mouthed at aggregations of flies, snapping the bill at those that are flushed. Only anecdotal information on diet is available. In salt ponds and on beaches, flies (Diptera) are undoubtedly an important prey. On Pacific Coast beaches and tidal flats, the following prey have been recorded in the diet: mole crabs (*Emerita analoga*), small crabs (*Pachygrapsus crassipes*), polychaetes (Neridae, *Lumbrineris zonata*, *Polydora socialis*, *Scoloplos acmaceps*), amphipods (*Corophium* spp., *Ampithoe* spp., *Allorchestes* spp.), sand hoppers (*Orchestoidea* spp.), tanadaceans (*Leptochelia dubia*), flies (Ephydridae, Dolicopodidae), beetles (Carabidae, Buprestidae, Tenebrionidae), clams (*Transennella* spp.), and ostracods (Page et al. 1995). In San Francisco Bay salt evaporation ponds the following prey have been recorded: flies (*Ephydra cinerea*), beetles (*Tanarthrus occidentalis*, Bembidion), moths (*Perizoma custodiata*) and lepidopteran caterpillars (Feeney and Maffei 1991).

Breeding - Feeney and Maffei (1991) monitored snowy plover nests in the Oliver Brothers/Baumberg region salt ponds during the 1989 breeding season. They located 66 nests, and 14 broods from nests which they did not find. Assuming the broods were from nests in locations they were studying, they located a seasonal nest total ranging from one nest per 1.1 hectare (ha) to one nest per 5.8 ha in four subregions of their salt pond study area. From all day watches of parent(s) with broods, they found the daily area covered by a brood ranged from 0.1-5.5 ha and averaged 1.6 ha. They noted that vegetation was used by chicks for hiding and for foraging. Northern harriers were observed hunting in areas where young snowy plovers were the only likely prey; an American kestrel was observed taking a snowy plover chick; and a peregrine falcon was seen taking an adult snowy plover. Ravens, ground squirrels, and California gulls also prey upon snowy plover eggs.

Roosting - In San Francisco Bay, roosts of snowy plovers occur on the salt pans of dry or partly dry salt evaporators, on barren to sparsely-vegetated interior salt pond levees, and on sandy tidal flats. Up to 300 snowy plovers have been found roosting in one salt evaporator in the Baumberg Tract during winter (Feeney and Cogswell, pers. comm.).

Movement - Snowy plovers are known to move between salt pond breeding, foraging, and roosting sites, and mudflat foraging sites during all seasons. A more detailed understanding of snowy plover movements in the San Francisco Bay would require tracking color-banded individuals.

Conservation and Management

Contaminants Risks - Little information is available. In 1996 several snowy plovers at Ocean Beach became oiled after a spill in San Francisco Bay.

Disturbance - Snowy plovers are disturbed by hikers, joggers, dogs off leashes which sometimes deliberately chase them, and by avian predators. It is not uncommon for plovers to fly back and forth over a roosting area in a tight flock for up to 20 minutes after having been attacked by a merlin or a peregrine falcon.

Protective measures - Several measures are used to reduce disturbance to nesting snowy plovers. Some coastal beaches have been closed or roped off. In other areas, a combination of informative signs and fencing of individual nests are used to protect snowy plover nests from predators and people. The U.S. Fish and Wildlife Service removes non-native predators at Monterey and San Francisco bays to improve snowy plover nesting success, as well as adult and chick survival rates.

Recommendations

This is a federally listed threatened species that cannot afford to lose habitat. Plans for tidal marsh restoration should attempt to encourage natural formation of salt pan habitat at bay's edge for potential plover use. A salt evaporation system should be preserved in the South Bay that produces medium to high salinity ponds, and that is large enough to support at least 300 breeding snowy plovers. Several salt pond sites should be provided, rather than one large contiguous salt pond area. South San Francisco Bay has recently had one of the largest breeding concentrations of snowy plovers on the western coast of the United States. The recovery plan for the Pacific Coast population will at minimum require that numbers of plovers in known high concentration sites not be reduced below recent levels.

Habitat elements important to snowy plover include mudflats and sandflats (used for feeding); salt pan (used for nesting and feeding); and unvegetated levees, islets, and beaches (used for nesting, feeding, and roosting). Important geographic regions are South Bay, Central Bay, and North Bay. Regional recommendations to support snowy plover are shown in **Table 6.2**.

Suisun - There is no documentation of snowy plover use of Suisun.

North Bay - Species nests in small numbers on North Bay salt ponds. Some habitat in this region of the Bay should be maintained; however, emphasis should be placed on enhancing habitat in the more heavily-used South and Central bay areas. An area of particular importance in the North Bay is Little Island.

Central Bay - Areas of importance include the Alameda Naval Air Station and the Oakland Airport. Outboard tidal flats from Roberts Landing to San Mateo Bridge should be maintained as foraging habitat.

The Hayward Area Recreation District (HARD) wants to manage the Oliver Brothers' property for snowy plovers. California Deptartment of Fish and Game and the U.S. Fish and Wildlife Service have agreed to this objective for this site. The goal of the management is approximately 50 breeding birds.

South Bay - The goal for the South Bay subregion should be to sustain at least 300 breeding snowy plovers. Areas of importance include East Bay salt ponds between the San Mateo and Dumbarton bridges; Salt pond systems south of the Dumbarton Bridge; and Oliver Brothers' property. Detailed recommendations for South Bay are provided in **Table 6.3**.

Research Needs

An up-to-date survey of the size of the breeding snowy plover population in San Francisco Bay is needed to determine if the population is continuing to decline. An effort to band snowy plovers in the San Francisco Bay area, as well as regular breeding and wintering season surveys for color-banded birds are needed to understand juvenile and adult snowy plover dispersal patterns between San Francisco Bay and coastal beaches. An analy-

Table 6.2 Regional Recommendations to Support Western Snowy Plover

Habitat Type	Recommendation
Salt Pond	Maintain sufficient mid- and high salinity salt pond systems to support at least 300 breeding snowy plovers.
Intertidal Flat	Maintain tidal flats outboard of marshes as foraging habitat.
Pan	Manage a salt pond system to provide sufficient salt pan and levees to support at least 300 breeding snowy plovers annually.

Table 6.3 Recommendations to Support Western Snowy Plover in the South Bay

Habitat Type	Recommendation
Salt Pond	Manage a salt pond system which, when combined with the Oliver Bros. property in the Central Bay, annually supports at least 300 nesting snowy plovers.
High Salinity Salt Ponds	Manage Oliver Bros. salt ponds for nesting snowy plovers from mid-March to mid-September.
Intertidal Flat	Maintain outboard tidal flats as foraging habitat.
Pan	Manage salt pond habitat to include sufficient salt pan and levees to support 300 breeding snowy plovers.

sis of breeding habitat characteristics (e.g. soil salinity, vegetative cover) and presence of breeding birds or measures of nesting success would be useful to better understand plover habitat use and to guide future management efforts.

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Marbled Godwit

Limosa fedoa

Gary W. Page
Catherine M. Hickey
Lynne E. Stenzel

Introduction

San Francisco Bay holds the second largest known wintering concentration of (15,000-20,000) marbled godwits in the world. It is partly for this reason that the godwit was chosen as a focus species by the Wetland Ecosystem Goals Project's Shorebird and Waterfowl Focus Team. Additionally, although marbled godwits are more restricted to estuarine habitats than the willet (*Catoptrophorus semipalmatus*) and the American avocet (*Recurvirostra americana*), their habitat requirements may well represent those of all large shorebird species as a group (e.g. willet, long-billed curlew (*Numenius americanus*), whimbrel (*Numenius phaeopus*), black-bellied plover (*Pluvialis squatarola*), and American avocet). A comprehensive management plan for San Francisco Bay Area wetlands will need to recognize the importance of expansive tidal flats as foraging habitat during ebbing tides for large shorebird species and will need to identify important roosting and alternative foraging habitat during high tides.

Description

The marbled godwit is a large (about 45 cm), mottled, cinnamon-buff and black shorebird, with long dark gray legs and a distinctive long, bicolored, pink and black slightly upturned bill (Palmer 1967, Hayman et al. 1986). The long-billed curlew is of similar coloration and size, but has a long distinctive decurved bill. The willet is also similar in size, but is grayer and has a much shorter straight bill.

Courtesy USGS/NBS

Breeding Biology - Although small numbers of marbled godwits breed in tundra areas of Alaska and James Bay (Ontario), most nest on the prairies of the United States and Canada. On the prairies, nesting probably begins in May and extends into August when the last young fledge. Clutch size is four with both sexes incubating for the suspected 21-23 day incubation period. Both sexes attend the precocial young which leave the nest permanently a few hours after hatching (Palmer 1967, Johnsgard 1981).

Migration Ecology - Autumn migration begins in early July and extends into October (and possibly November) with the earliest adults likely beginning to move about a month before the young of the year, as in other shorebirds (Shuford et al. 1989). Although the winter destination of some godwits is the Atlantic coast of Florida and the Gulf of Mexico, most travel to the Pacific coast of the United States and Mexico for winter (Palmer 1967, Hayman et al. 1986). Spring migration may begin in March but is most noticeable in April and May (Palmer 1967, Shuford et al. 1989). Except for the Great Salt Lake, where tens of thousands of marbled godwits stage during spring and fall, migrating godwits are rare during migration in interior wetlands of western North America (including the Central Valley of California; PRBO, unpubl. data). There is some migration of godwits along the Pacific Coast in spring and fall.

Wintering Ecology - This species is very restricted to coastal habitats in winter where it associates most commonly with willets, long-billed curlews, American avocets, and black-bellied plovers. The regions with the largest concentrations of wintering godwits are the coast of California, the western coast of Baja California, and the eastern coast of the Gulf of California (PRBO, unpubl. data; B. Harrington, unpubl data; Morrison et al. 1992, Page et al. 1997).

Distribution and Abundance

North America - The North American (and world) population size of the marbled godwit is likely in the low hundreds of thousands of birds (Page and Gill 1994). During the past 150 years the breeding range of the marbled godwit has shrunk significantly suggesting the population is now smaller than before the colonization of North America by caucasians (Page and Gill 1994).

Marbled godwits breed from the central Prairie Provinces of Canada southward through Montana, the Dakotas and western Minnesota. Small isolated breeding populations also exist in Alaska and at James Bay, Ontario. They winter from California, Texas, and Florida, south to Central America, but rarely to South America (Johnsgard 1981).

Pacific Coast - Along the Pacific Coast, the largest concentrations of wintering godwits are likely on the coast of California, the western coast of Baja California, and the eastern coast of the Gulf of California (PRBO, unpubl. data; B. Harrington, unpubl data; Morrison et al. 1992). Very small numbers of godwits also winter at Willapa Bay on the Washington Coast (PRBO, unpubl. data).

San Francisco Bay - Marbled godwits occur in all regions of San Francisco Bay. The winter population size of as many as 20,000 individuals is the second largest known concentration of wintering marbled godwits in the world (Page et al. 1997). During migration, as many as 32,000 marbled godwits have been recorded in San Francisco Bay (PRBO, unpubl. data).

Suisun - Small numbers (low hundreds) of marbled godwits are found on the tidal flats of Suisun Bay.

North Bay.- Typically about 30% of the Bay population of marbled godwits are found in San Pablo Bay (**Figure 6.10**).

Central Bay - Central San Francisco Bay typically holds only 10-20% of the Bay total of godwits.

South Bay - During all seasons, the largest numbers of marbled godwits occur in south San Francisco Bay, usually 50-60% of the Bay total (**Figure 6.11**).

Historical Information

Godwit populations in California were believed to have decreased markedly in number by 1910 due to market hunting and destruction of breeding habitat (Grinnell et al. 1918). Grinnell and Miller (1944) report that population recovery began about 1910 and was nearly complete by 1944.

Population Trends

There is no information available on how population numbers may have changed in San Francisco Bay historically. Continentally, the breeding range of marbled godwits has shrunk during the past 150 years, and the population has also likely declined (Page and Gill 1994).

Habitat Use and Behavior

Foraging - This species characteristically probes deep into sandy to muddy substrates for invertebrate prey. Tidal flats and sandy beaches are the principal feeding habitat with wet to shallowly-flooded pastures and lawns sometimes used on high tides. Some foraging also occurs in salt marshes and occasionally on rocky reefs. In San Francisco Bay, marbled godwits forage primarily on tidal flats and to a much lesser degree in salt marshes, seasonal wetlands, and possibly salt ponds. Prey of marbled godwits in San Francisco Bay include the marine polychaete (*Neanthes succinea*), the gastropod (*Ilyanassa obsoleta*), and the pelecypods (*Gemma gemma*, *Mya arenaria*, *Macoma inconspicua*; Recher 1966). At

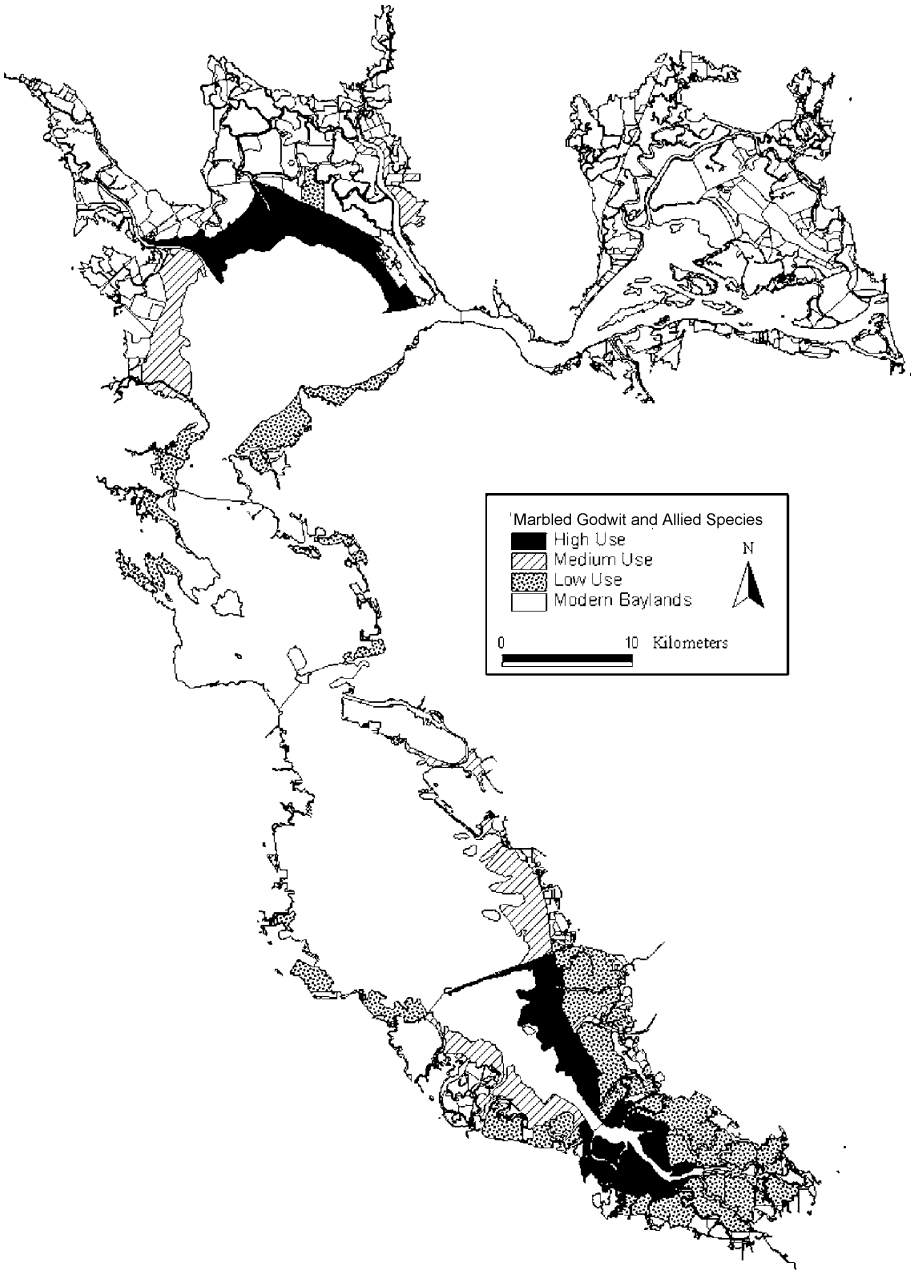

Figure 6.10 Relative Use of Different Baylands Areas by Marbled Godwit, Willet, Whimbrel, and Long-billed Curlew Combined

Data from PRBO Pacific Flyway Project, 1988-1992. Unpublished data (data from Suisun not presented).

Bolinas Lagoon, polychaetes are the godwit's chief prey although amphipods, decapods, small bivalves, fish, adult insects, tanaidaceans, ostracods, and gastropods are also taken (Stenzel et al. 1983). Elsewhere on the California coast, polychaetes, adult flies and gastropods have also been reported in the godwit's diet (Reeder 1951, Holmberg 1975). On sandy beaches, mole crabs (*Emerita analoga*) are also important prey (G. Page, pers. obs.).

Roosting - In San Francisco Bay, godwits congregate into flocks as large as 1,000 or more birds to roost on tidal flats when they are not covered by tides and during high tides in shallowly-flooded salt evaporation ponds, open areas in salt marsh, or other barren to moderately vegetated habitats such as salt pond levees or islands (PRBO, unpubl. data; Kelly and Cogswell 1979).

Movement - Marbled godwits forage in deeper water below the tide line compared to most other shorebirds and usually concentrate near the tide line as it advances and retreats over the flats. Roosting behavior is usually associated with high tides and feeding with low to moderately-high tides. In South San Francisco Bay, Kelly and Cogswell (1979) report the usual distance traveled between roosting and feeding areas to be about 1,000 m. They found color banded individuals consistently used the same feeding and roosting areas and some of these individuals took up residence for eight to nine months during the non-breeding season.

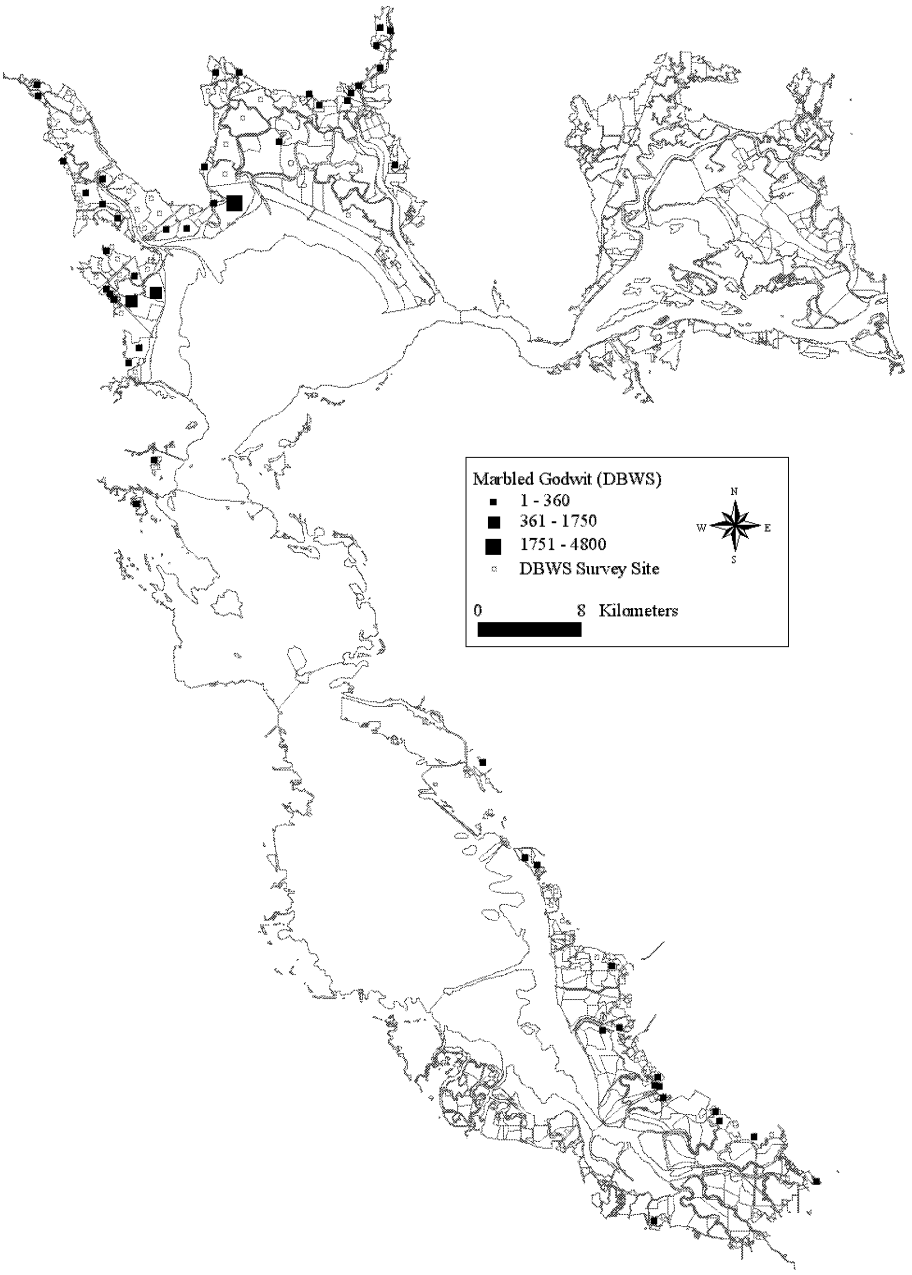

Figure 6.11 Maximum Counts of Marbled Godwit

Bayland data from the Diked Baylands Wildlife Study (DBWS),1982-1989 (USFWS, *in prep.*).

Conservation and Management

Contaminant Risks - Little to no information is available.

Disturbance - Roosting or foraging birds may be flushed by people approaching too closely, by avian predators (particularly *Falco peregrinus*), or by unleashed dogs which chase them, as well as other shorebirds. Roosting birds have been flushed by jet skiers and wind surfers (N. Warnock, pers. comm.)

Recommendations

San Francisco Bay holds the largest wintering concentration of marbled godwits in the United States, and numerous large shorebirds use salt pond systems as high tide roosting and foraging habitat. Therefore, we need to preserve enough acreage of salt pond habitat to hold large numbers of all large shorebird species. Since alternative sites should be available, rather than one large contiguous salt pond area, multiple roosts should be located in all regions of the Bay.

Important habitat elements for marbled godwits include mudflats and sandflats (used for foraging and low-tide roosting); pan, beach, and unvegetated levees and islets (used for roosting); and seasonal wetlands (when wet, used for foraging and roosting). Birds also use man-made structures for roosting.

The geographic subregions of most importance to marble godwits are South Bay, North Bay, and Central

Bay. Regional recommendations to support marbled godwits are shown in **Table 6.4**.

Suisun - Small number of marbled godwits forage on the tidal flats of Suisun Bay and roost in the managed wetlands. Areas of importance include the tidal flat of Honker Bay and the managed wetlands. All intertidal flat habitat should be maintained to provide foraging. Some shallow, sparsely vegetated managed marsh should be maintained for roosting.

North Bay - Areas of importance within the North Bay include all areas of tidal flats, seasonal wetlands, and salt ponds. Pilings extending into the Bay and the jetty in Carquinez Straights are important willet roosts. To maintain shorebird populations in the North Bay high tide roosting sites must be available. **Table 6.5** provides detailed recommendations for the North Bay.

Central Bay - It is important to preserve all existing roosts and investigate the potential to establish more roosting sites in the Central Bay. All existing tidal flat outboard of marshes should be maintained, as should Marta's Marsh and Shorebird Marsh in Marin County.

South Bay - All tidal flat is important for foraging and roosting at low tide. Maintain outboard flats and increase tidal flat along channels and in salt marsh. Mid- and high salinity ponds are important for roosting and foraging, and provide American avocet nesting habitat. Maintain some mid- to high salinity ponds as roosting and foraging habitat, and manage the former Oliver Brothers salt ponds for roosting shorebirds from September to March.

If the amount of salt pond habitat is reduced, maintain sufficient and multiple roosting sites for the current population of at least 100,000 large shorebirds. If we want to retain nesting sites for the American avocet, we need to retain some salt ponds or create alternate nesting habitat (salt pan).

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Table 6.4 Regional Recommendations to Support Marbled Godwit

Habitat Type	Recommendation
Intertidal Flat	Maintain tidal flat outboard of marshes; Increase tidal flat in salt marshes by creating wide channels with exposed flat at low tide.
Salt Ponds	Maintain some shallowly-flooded salt ponds for high tide roosting.
Treatment Pond	(Possibly potential roosting areas.)
High Tidal Marsh	Create barren to sparsely vegetated areas above high tide for roosts.
Farmed/Grazed Bayland	(When wet, could provide high tide foraging habitat in winter.)

Table 6.5 Recommendations to Support Marbled Godwit in the North Bay

Habitat Types	Recommendation
Intertidal Flat	Maintain all outboard flats; Increase channel tidal flat in salt marshes.
Salt Pond	Manage former Cargill intake pond for roosting and foraging shorebirds.
Unvegetated Shore	Maintain present acreage
Muted Tidal Marsh	Manage muted tidal diked marsh west of intake ponds and south of Napa Slough for roosting and foraging shorebirds.
Farmed/Grazed Bayland	Enhance seasonal wetlands as high tide foraging and roosting areas.

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Black Turnstone

Arenaria melanocephala

Stephen L. Granholm

Introduction

In the San Francisco Estuary, black turnstone is the most numerous of a group of uncommon shorebirds that typically use rocky unvegetated shores. Other species in this group include ruddy turnstone (*Arenaria interpres*), surfbird (*Aphriza virgata*), spotted sandpiper (*Actitis macularia*), black oystercatcher (*Haematopus bachmani*), and wandering tattler (*Heteroscelus incanus*). These species occur in the Estuary as migrants and winter residents. They do not breed here, except for a few pairs of oystercatchers and an occasional pair of spotted sandpipers.

Description

The black turnstone is a short-legged, short-billed shorebird, about 23 cm long, with a blackish back, chest, and legs, and a white belly. In feeding plumage it has some white speckling and a white dot in front of the eye. It displays a striking black and white harlequin pattern in flight.

Distribution and Abundance

North America/Pacific Coast - Black turnstones are found exclusively along the Pacific coast of North America. They breed in western and southern Alaska and winter from southeastern Alaska south to southern Baja California and central Sonora, Mexico (Johnsgard 1981). A few occur inland during migration.

Black turnstones are present along the California Coast from about mid-July to mid-May (Cogswell 1977, McCaskie et al. 1979), and small numbers of nonbreeders remain through the summer (Zeiner et al. 1990).

San Francisco Bay - Total counts of black turnstone for the Estuary have ranged from 40-137 birds in fall, 69-144 in winter, to 212 birds in spring (PRBO, unpubl. data).

Courtesy USGS/NBS

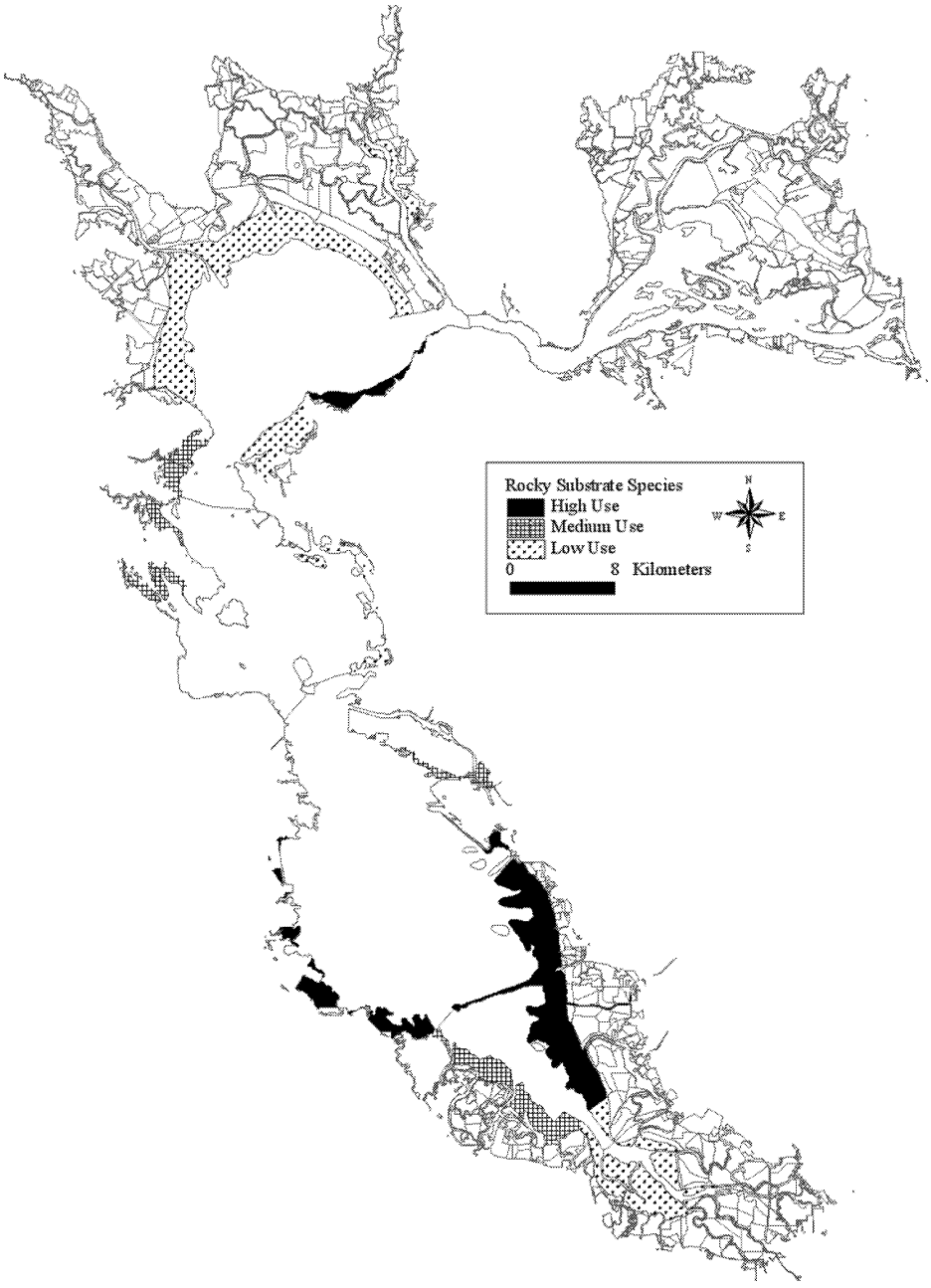

Figure 6.12 Relative Use of Various Tidal Flat and Adjacent Shoreline Areas by Rocky Substrate Species (Black Turnstone, Ruddy Turnstone, Surfbird, Spotted Sandpiper, Black Oystercatcher, and Wandering Tattler)

Data from PRBO Pacific Flyway Project, 1988-1992. Unpublished data.

Probably these counts underestimated black turnstone numbers, however, because the counts focused on intertidal mudflats and sandflats, rather than rocky unvegetated shores. Black turnstones do not breed in the Bay Area.

Suisun - Apparently, this species does not occur regularly east of the Carquinez Bridge.

North Bay - Black turnstones are found along the eastern shore of San Pablo Bay, primarily south of Hercules. Few are found on the western and northern shores of San Pablo Bay (north of Point San Pedro; **Figure 6.12**).

Central Bay - This species occurs widely throughout the Central Bay, in suitable habitat (**Figure 6.12**).

South Bay - In South Bay, black turnstones are found primarily north of the San Mateo Bridge, but smaller numbers are found farther south (**Figure 6.12**).

Historical Information

No information.

Population Trends

No information.

Habitat Use and Behavior

Foraging - On their wintering grounds, black turnstones feed primarily on rocky unvegetated shores, including rocky breakwaters and riprap, as well as natural rocky shorelines. They also feed on intertidal mudflats, sandflats, and sandy beaches.

Black turnstones pick food from the surface or turn over seaweed, rocks, or shells to search for prey. They feed mostly on barnacles, limpets, and other small mollusks and crustaceans (Johnsgard 1981, Paulson 1993). Black turnstones usually forage and roost in small flocks of a few birds to a few dozen (Paulson 1993).

Roosting - They roost primarily on rocky unvegetated shores above the tide level, on relatively undisturbed sites such as breakwaters, islets, and inaccessible shorelines.

Movement - Black turnstones move from their foraging grounds to nearby roosting sites at high tides.

Conservation and Management

Contaminant Risks - No specific information.

Disturbance - Frequent disturbance by people and dogs could reduce this species' ability to accumulate sufficient energy reserves for migration.

Recommendations

The black turnstone population in the San Francisco Estuary is probably limited by the availability of rocky intertidal habitat with an adequate food supply. Natural rocky shorelines are very limited in extent, and riprapped shorelines probably have less abundant invertebrate prey than natural shorelines. Like other shorebirds, this species also requires undisturbed roost sites.

Regionwide goals should include maintaining or increasing population levels within the species' current range in the San Francisco Estuary. This will require preservation of natural and semi-natural rocky shorelines and other important feeding and roosting areas, especially areas with an abundant invertebrate population. Riprap habitat is also used by these birds, but a loss of this habitat is acceptable if unavoidable as part of tidal marsh restoration. Preservation of roosting areas must include protection from disturbance by people and dogs.

Areas of importance to black turnstones are primarily found in Central Bay, North Bay (eastern portion), and South Bay (northern portion). Important habitat elements are rocky shore and unvegetated levees and islets (used for roosting). Some of the shorebirds associated with rocky substrates, in particular, ruddy turnstones, also forage on mudflat and sandflat. Regionwide goals thus should include maintaining current acreages of unvegetated shore and intertidal flats.

Suisun - Maintain current acreage of unvegetated shore and intertidal flat.

North Bay - An area of importance to black turnstones is along the eastern shore of the North Bay, south of Hercules. There is currently very little use by this species north of Hercules. Subregional goals should include maintaining current acreage of unvegetated shore and intertidal flat.

Central Bay - Maintain current acreage of unvegetated shore and intertidal flat.

South Bay - Maintain current acreage of unvegetated shore and intertidal flat.

Research Needs

Future surveys should map rocky intertidal habitats in the Estuary and identify significant feeding and roosting areas for black turnstones and other rocky intertidal shorebirds. Foraging studies should be conducted to determine the relative importance of natural and semi-natural rocky shorelines, compared to riprap and other habitats.

Acknowledgments

I thank Janice Alexander for her assistance with this account.

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Red Knot

Calidris canutus

Catherine M. Hickey
Gary W. Page
Lynne E. Stenzel

Introduction

The red knot is a high-arctic breeder and a long distance migrant. Knots are most abundant on the Pacific coast of North America during spring migration and less abundant during fall (Page et al. 1979, Paulson 1993). In winter, significant numbers (hundreds to thousands) of knots appear to be localized in distribution into three areas on the Pacific coast of North America: San Francisco Bay, San Diego Bay, and Laguna Ojo de Liebre, Baja California, Mexico (PRBO, unpubl. data). In San Francisco Bay Area wetlands, knots are also very localized in distribution. The importance of San Francisco Bay, and of specific sites in the region, to the red knot should warrant special concern for this species in any comprehensive management plan for San Francisco Bay Area wetlands. Such a plan should include a combination of extensive intertidal flats as foraging habitat for the knot, and adequate, undisturbed high tide roost sites. Because red knots frequently associate with dowitchers (*Limnodromus* spp.), dunlins (*Calidris alpina*) and black-bellied plovers (*Pluvialis squatarola*), management plans to preserve, enhance, or restore habitat for red knots may also benefit these other species.

Description

The red knot is the second-largest calidrid, about the same size of dowitchers. Knots look heavy and rounded in shape (Hayman et al. 1986). The bill is blackish and faintly downcurved, the iris is dark brown, and the legs are rather short. In nonbreeding or juvenile plumage, knots have mostly white underparts, rather plain gray upperparts, gray streaking on the breast and upper belly, and greenish legs. Breeding-plumaged adults have dark gray legs, chestnut-red face and underparts, gray and black speckled backs, and white undertail coverts (Paulson 1993). Knot flight feathers are blackish, with distinct but narrow white wing bars, the rump is pale gray, and the tail shows broad brown bars and narrower white ones (Hayman et al. 1986).

Courtesy USGS/NBS

Breeding Biology - Red knots breed inland on moist tundra and upland glacial gravel (Hayman et al. 1986). Nesting begins in late May and extends into August when the last young fledge (Harrington 1996). Knots lay four eggs at approximate one day intervals. Incubation lasts 21-23 days. Both sexes incubate, but the males primarily tend the brood. The fledgling period is approximately 18 days (Johnsgard 1981).

Migration Ecology - Red knots migrate long distances and concentrate in fewer areas than most other arctic breeding shorebirds. They are primarily coastal migrants, occurring only rarely inland in spring and fall. They are strictly coastal in winter (Hayman et al. 1986).

Wintering Ecology - Like the majority of shorebirds in San Francisco Bay, red knots feed primarily on tidal flats. At high tide they roost in flocks, particularly in salt ponds in South San Francisco Bay.

Distribution and Abundance

North America - There are three recognized subspecies of red knots that occur in North America. *C. c. islandica* breeds in the high arctic of Canada and Greenland and winters in Great Britain, France, and the Wadden Sea. *C. c. rufa* breeds in the central Canadian arctic and winters in southeastern North America, the Caribbean, parts of the northern coast of South America, and in the southern parts of South America. Harrington et al. (1988) estimate a total population of 100,000-170,000 for this subspecies. Little is known about the third subspecies, *C. c. roselaari*, which is believed to breed in northern Siberia on Wrangel Island and in Alaska and to migrate and winter along the Pacific coast of North America (Tomkovich 1992). Currently, there are no population estimates for this subspecies. A fourth subspecies, *C. c. rogersi*, breeds in northeastern Siberia and perhaps in Alaska, and winters primarily in Australia and New Zealand but possibly also on the Pacific coast of South America.

Pacific Coast - Red knots are significantly more abundant along the Pacific coast of North America during spring migration than during fall migration. Grays Harbor and Willapa Bay in Washington appear to be important staging areas for the knot in spring migration. The fall migration route of the large numbers of knots that migrate along the coast during the spring is not well-known (Paulson 1993). In winter, significant numbers of knots appear to have a localized distribution into three main areas: San Francisco Bay, San Diego Bay and La-

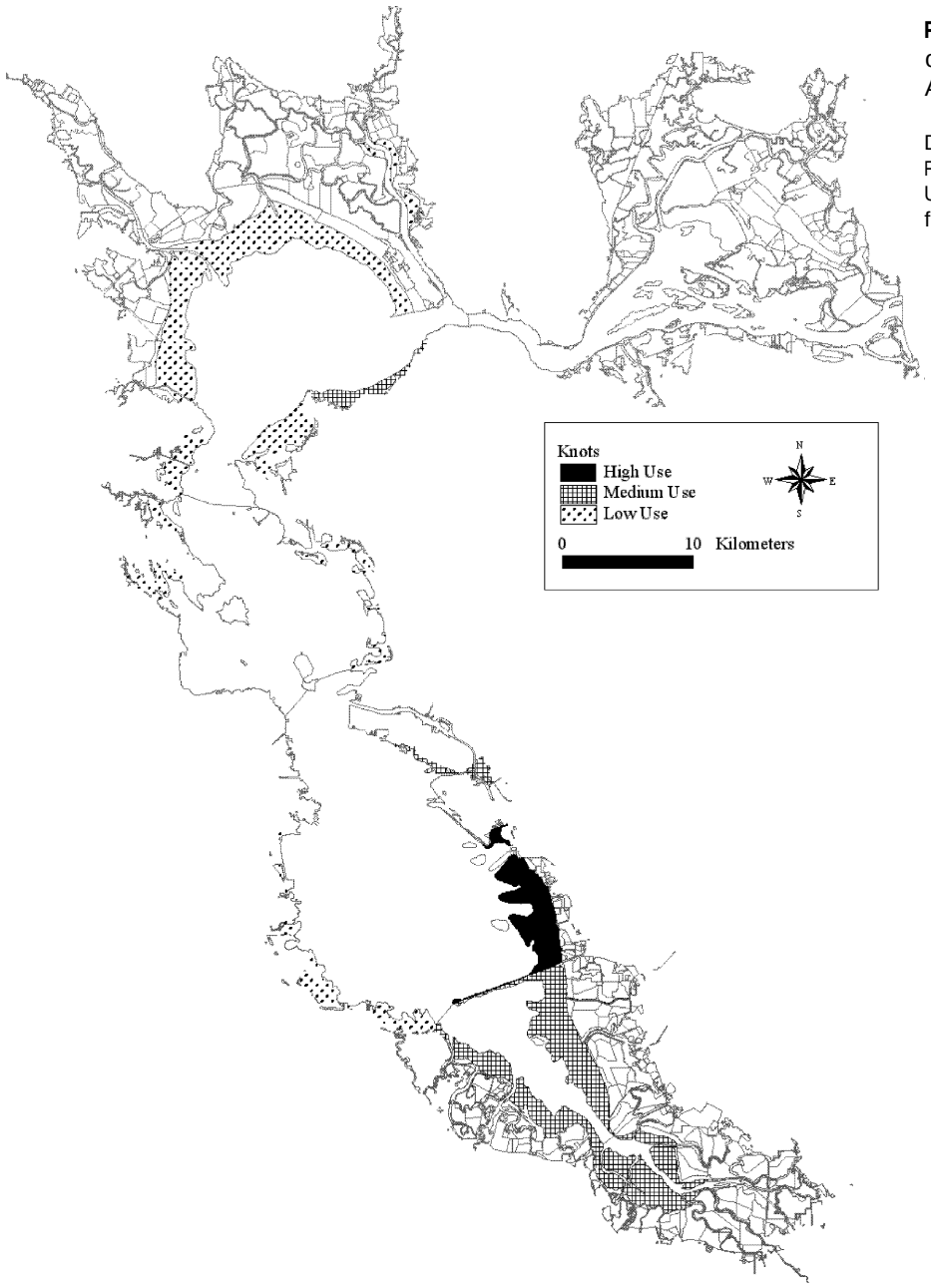


Figure 6.13 Relative Use of Different Mudflat Areas by Red Knots

Data from PRBO Pacific Flyway Project, 1988-1992. Unpublished data (data from Suisun not presented).

guna Ojo de Liebre, Baja California, Mexico. Knots do not winter regularly in the Pacific Northwest.

San Francisco Bay - Small numbers of red knots occur scattered in various wetland habitats around San Francisco Bay. Larger numbers of knots (hundreds to over one thousand) have a more localized distribution in the Bay. Within San Francisco Bay, 18 to 2,100 red knots were found on Point Reyes Bird Observatory (PRBO) counts.

Suisun - Probably uncommon to rare in Suisun.

North Bay - Large numbers of knots were recorded on intertidal flats just north of Pinole Point, Contra Costa County, but were rarely found elsewhere in San Pablo Bay on PRBO counts (**Figures 6.13** and **6.14**; PRBO counts).

Central Bay - Knots were reported on intertidal flats just north and south of the San Mateo Bridge, Alameda County. Up to 100% of the San Francisco Bay population was found in the Central Bay on PRBO counts. (**Figure 6.13**; PRBO counts).

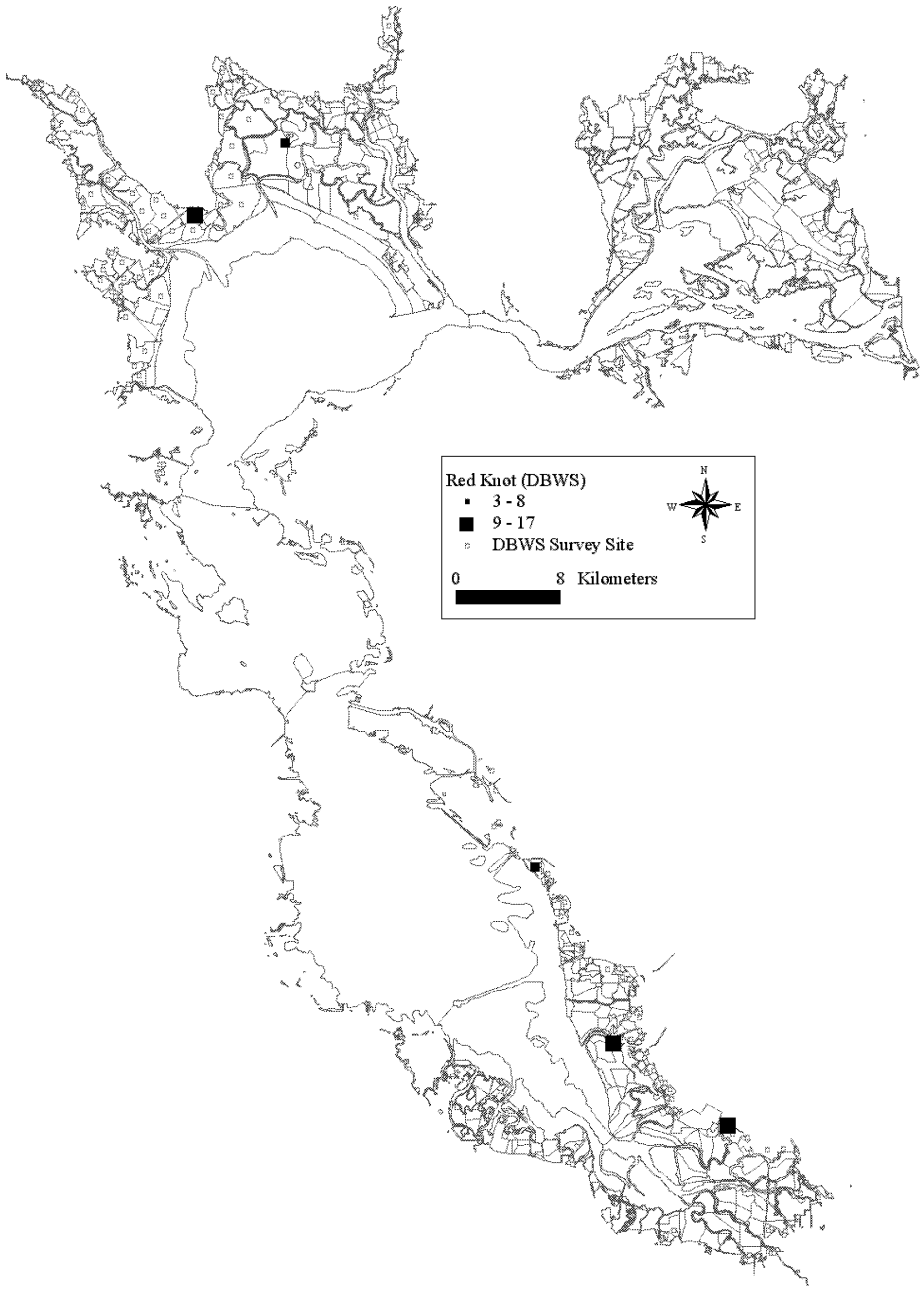
South Bay - Knots have been reported in two salt pond complexes in Alameda County (PRBO, unpubl. data). Up to 100% of the San Francisco Bay total was found in the South Bay (**Figures 6.13** and **6.14**; PRBO counts).

Historical Information

There is no historical population estimate for red knots in San Francisco Bay. Red knot populations in North

Figure 6.14 Maximum Counts of Red Knot

Bayland data from the Diked Baylands Wildlife Study (DBWS),1982-1989 (USFWS, *in prep*.).



America suffered from intense hunting. Since legal protection was afforded, their status has improved.

Population Trends

No information.

Habitat Use and Behavior

Foraging - Knots are specialized feeders, requiring concentrated, rich food resources (Harrington 1996). Knots typically forage in cohesive flocks, feeding mainly by probing, but also by pecking at surface foods (Hayman et al. 1986). In Bolinas Lagoon, Marin County, California, Stenzel et al. (1983) found that several bivalve species (*Transennella* spp., *Protothaca* spp., *Gemma* spp., *Macoma* spp., *Mytilus* spp., and *Clinocardium* spp.) were the knot's primary prey. Other prey items included errant polychaetes (*Lumbrinerius* spp. and *Glycinde* spp.), gastropods, alga-dwelling and tube-dwelling amphipods, and trace amounts of small crustaceans, Foraminifera, tanaidaceans, and sedentary polychaetes. Other shorebird diet analyses have also determined molluscs to be the primary prey item of red knots on the western coast of North America (Sperry 1940, Recher 1966). On the Atlantic Coast, eggs of horseshoe crabs (*Limulus polyphemus*) are a staple. Adult and larval insects, as well as plant material are the primary prey items on the breeding grounds.

Roosting - Red knots are known to form dense, sometimes mixed, roosting flocks. In San Francisco Bay,

salt evaporator ponds in the Hayward area appear to be important roosting habitat for knots.

Movement - Little is known about red knot movement between habitat types in the San Francisco Bay Area.

Conservation and Management

Contaminant Risks - Little or no information is available, but because red knots are localized in distribution, they are particularly vulnerable to contaminants and potential oil spills.

Disturbance - Red knots, like most other shorebirds, may be flushed by people approaching too closely, by avian and terrestrial predators, or by unleashed dogs that chase them. Knots should warrant special concern in development and management plans in the San Francisco Bay region.

Recommendations

San Francisco Bay is one of three main red knot wintering areas along the western coast of the United States. Since this species is relatively rare compared to other species occurring in the Bay, special consideration should be given to its habitat requirements and to specific areas of known use. Its habitat requirements should not be expected to be an umbrella for the associated species. Salt ponds currently used by red knots for roosting may also be used as alternate foraging habitat.

Within the Bay, areas of importance to red knot are found in North Bay, Central Bay, and South Bay. Mudflat and sandflat are important for roosting and foraging, and unvegetated levees, islets, beaches, and pans are used for roosting. Goals for this species should include maintaining tidal flat outboard of marshes for foraging habitat, and some salt ponds on the eastern side of the South Bay for roosting sites.

Suisun - There is no documentation of red knots using Suisun.

North Bay - The tidal flats between Point Pinole and Carquinez Straight are important and should be maintained. Investigation is needed to identify the important roosting areas in the North Bay subregion.

Central Bay - Central Bay tidal flats along the Hayward shoreline appear to be the most important site for red knots in the entire Bay. Roosting areas for red knots in the Alameda area need to be identified. All tidal flats on the eastern side of the Bay should be maintained and improved. The Oliver Brothers salt ponds should be maintained as roosting habitat.

South Bay - Baumberg/Hayward area salt ponds are known to hold roosting red knots. Though salt ponds are primarily for roosting, they also may be used as alternate foraging areas when intertidal flats are covered at high tide.

All tidal flat should be maintained for foraging, and the amount of flat along channels in tidal marsh should be increased. Some salt ponds should be preserved for roosting sites, especially in the Baumberg area. The Oliver Brothers salt ponds should be maintained as roosting habitat.

Research Needs

Substrate and invertebrate sampling from various intertidal flats around San Francisco Bay and San Pablo Bay would help determine whether known areas of consistent red knot concentration have a unique combination of substrate and/or food resources.

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Western Sandpiper

Calidris mauri

Nils Warnock
Sarah E. Warnock

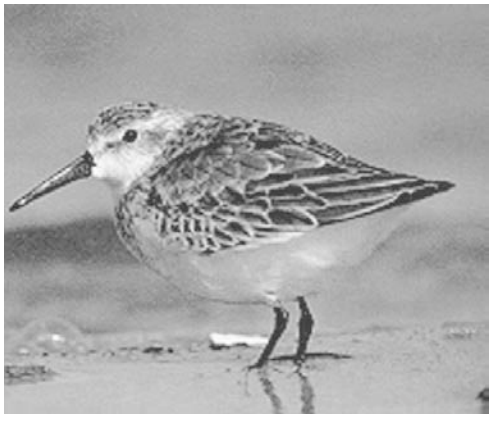
Introduction

The western sandpiper is the most abundant shorebird of California during fall and spring migration and the second most abundant during the winter. Largest concentrations of western sandpipers occur at coastal estuaries, but during the spring and to a lesser extent the fall, interior sites such as the western Great Basin, the Central Valley, and the Imperial Valley may host tens to hundreds of thousands of migrants. In winter, this species is more restricted to marine habitats than associated species, including least sandpiper, dunlin, and semipalmated plover. All the above species use tidal flats, salt ponds, managed wetlands, and seasonal wetland habitats in the Bay.

Description

Western sandpipers are marginally the largest of the stints. The species is sexually dimorphic with males typically smaller in size than females (Page and Fearis 1971). In basic plumage, they are pale grey with brown streaking on the crown, with white underparts. Fine, blackish streaks often join across the breast, usually heavier streaking than in semipalmated sandpipers with whom they share the special feature of partial webbing between the toes. Their typically longer, heavier, and decurved bill is also a helpful distinguishing factor. During breeding season, they have a distinctive dark streaking on their breasts with "V's" or arrowheads on flanks, and usually much more rufous in upper scapulars and head than other species likely to be encountered.

Breeding Biology - Western sandpipers are monogamous, bi-parental sub-Arctic and Arctic breeders. At least some begin breeding after their first year (Holmes 1971). Generally, they only lay one clutch per season, but will lay a replacement clutch if the first is lost early in the breeding season. Mean clutch completion in western Alaska occurs between 25 May and 5 June (Holmes 1972). Western sandpipers generally lay four eggs. Favored nesting habitat is moist to wet graminoid tundra, but they will also occasionally breed on lower mountain slopes (Wilson 1994). They nest in depressions in the ground typically lined with grass and under a dwarf birch (Wilson 1994). Mean incubation period is 21 days (Holmes 1973). Hatch success is 84% at the Yukon-Kuskokwim Delta, Alaska (Holmes 1972) and 55% at Nome, Alaska (Wilson 1994). Major nest predators include jaegers and foxes.



Courtesy USGS/NBS

Migration Ecology - The global distribution of western sandpipers is skewed by sex. Female birds are more likely to winter at more southernly sites than males (Page et al. 1972, Harrington and Haase 1995). In California and San Francisco Bay, winter populations of western sandpipers are skewed towards males (Page et al. 1972).

At San Francisco Bay, during fall migration, adults arrive about a month earlier then juveniles (late June, July); followed by juveniles (August through October). During spring migration, peak numbers occur from 20 April though 5 May; males are followed by females (N. Warnock, unpubl. data). The length of stay at San Francisco Bay of northward migrating western sandpipers radio marked there was 9.1 ± 4.6 days (n = 58 birds), although these stays may have been prolonged due to temporary effects of capturing the birds (Bishop and Warnock 1998, Warnock and Bishop 1998). Birds radio marked at San Francisco Bay have been detected at all major coastal estuaries between the Bay and the Yukon-Kuskokwim Delta (with the exception of sites in Oregon, a state not monitored). Breeding destination of many of the birds migrating through the Bay appears to be the Yukon-Kuskokwim Delta (Bishop and Warnock 1998). Breeding birds from the Seward Peninsula also have been detected at San Francisco Bay, as well as wintering birds from Panama and Mexico (Butler et al. 1996).

Spectacular concentrations of western sandpipers are found during the northward spring migration with hundreds of thousands of birds concentrating at such sites as San Francisco Bay, CA, Grays Harbor, WA, Fraser River Delta, BC, Stikine River Delta, Alaska and the Copper River Delta, Alaska (Iverson et al. 1996). During spring, exchange of western sandpipers between Bolinas Lagoon (an estuary approximately 14 km northwest of San Francisco Bay) and North San Francisco Bay was found (Warnock, unpubl. data).

Wintering Ecology - First-year birds (26.6 ± 3.6 km^2) have larger winter home ranges than adults (17.2 ± 2.5 km^2), but no significant differences in size of home

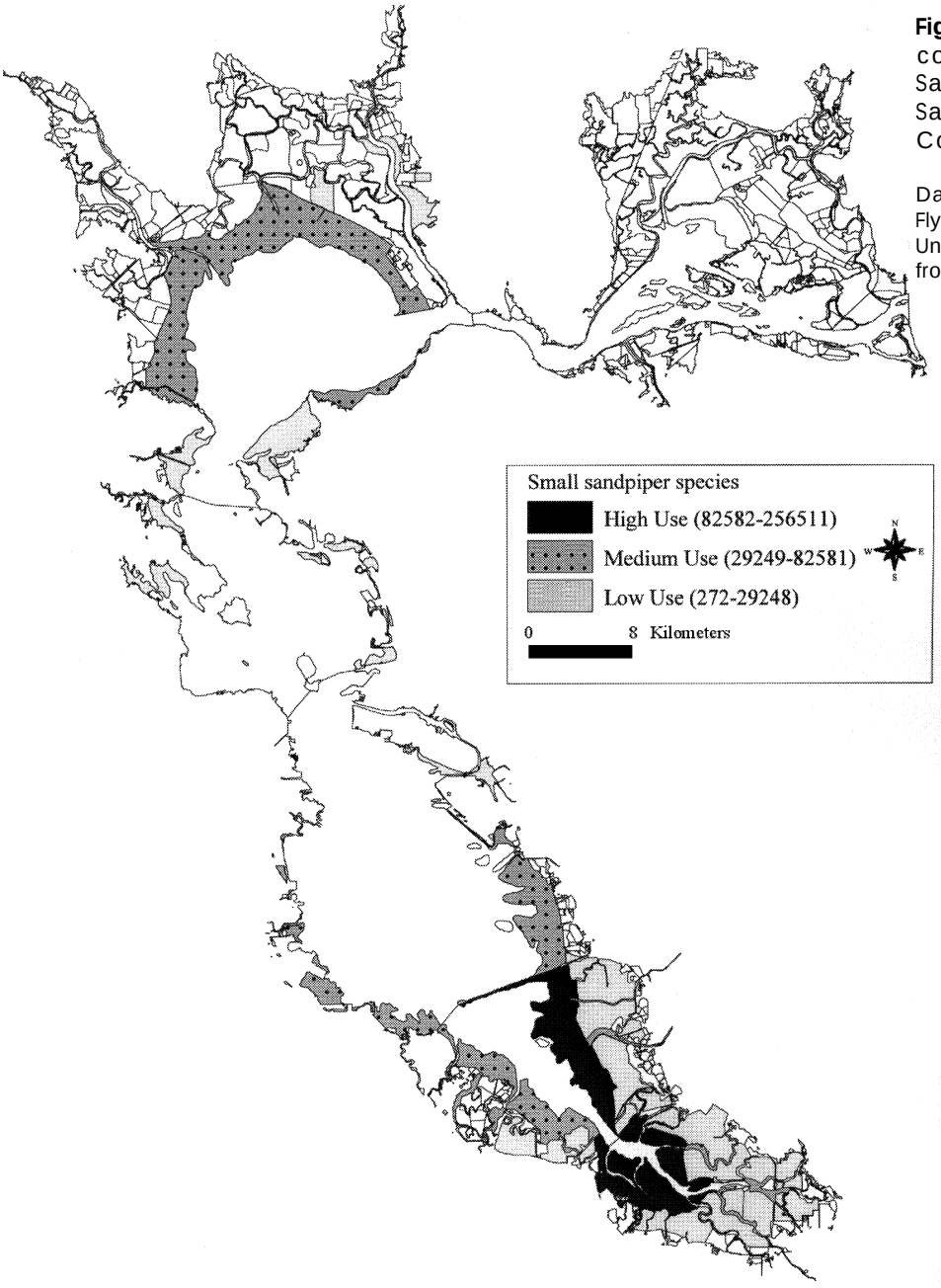


Figure 6.15 Maximum counts of Western Sandpiper, Least Sandpiper, and Dunlin Combined

Data from PRBO Pacific Flyway Project, 1988-1992. Unpublished data (data from Suisun not presented).

range were found between sexes (Warnock and Takekawa 1996). Individual birds are strongly site-specific within San Francisco Bay.

Distribution and Abundance

North America - Western sandpipers breed in western Alaska from the Alaska Peninsula up to the North Slope of northern Alaska. Small numbers also breed in northeastern Russia. They commonly winter from Washington through the southeastern United States, and south through Mexico and Central America to northern Peru.

Pacific Coast - The largest winter concentrations are found from San Francisco Bay south to Panama. Areas of largest concentrations include San Francisco Bay, Lagunas Ojo de Liebre and Guerro Negro in Baja California, Mexico (Page et al. 1997), western coast of Mexico in the Gulf of California, and coast of Panama.

San Francisco Bay - Western sandpipers are found in all parts of the San Francisco Bay Estuary. A comprehensive April count of shorebirds counted over 555,000 western sandpipers (Stenzel and Page 1988). As many as 707,000 were found during five additional spring counts. Largest numbers were found in areas of the South Bay with large expanses of mudflats at low tide backed by salt pond complexes **(Figures 6.15** and **6.16)**.

Suisun - Point Reyes Bird Observatory (PRBO) surveys indicate as many as 5,000 western sandpipers in

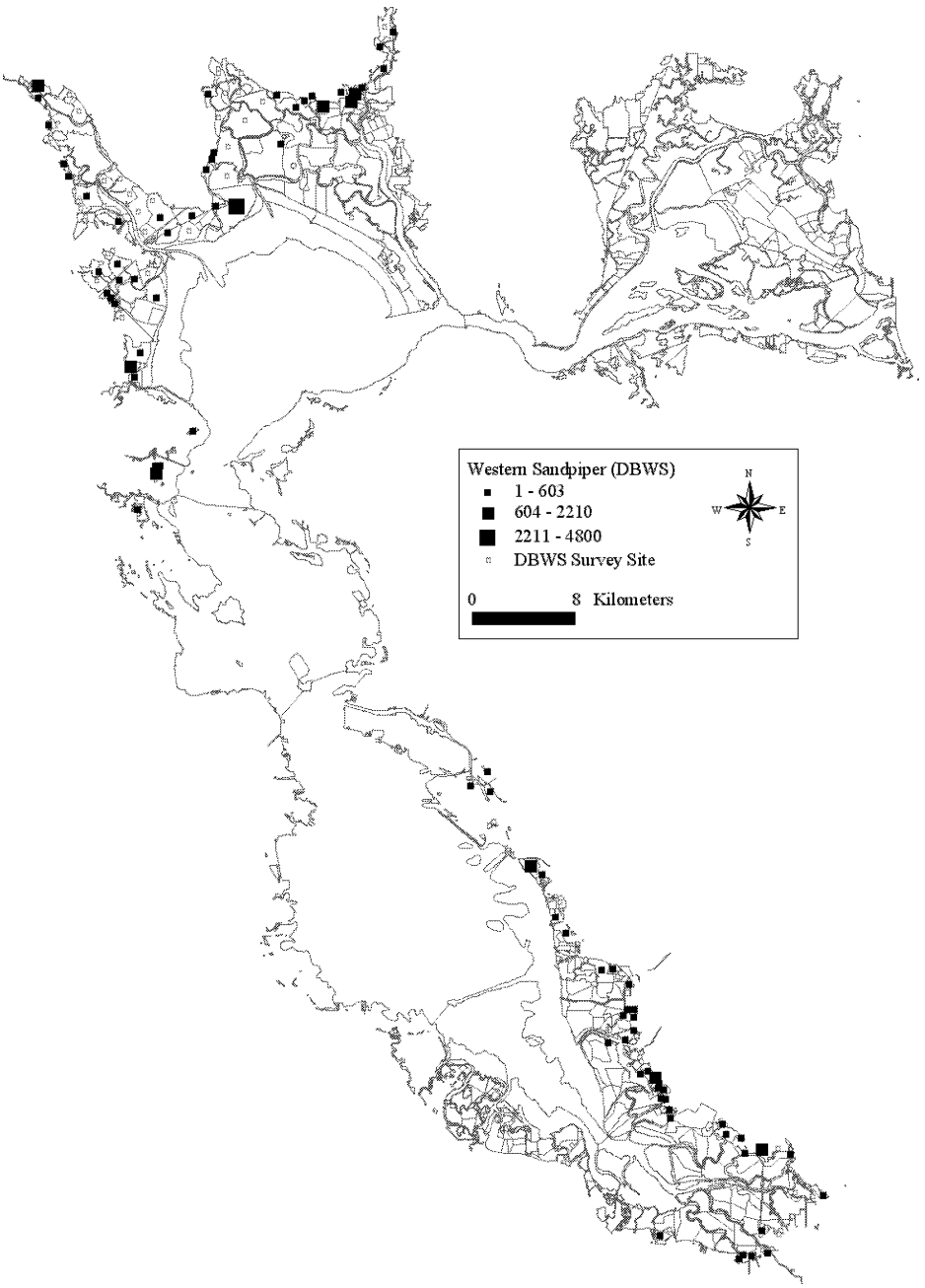


Figure 6.16 Maximum Counts of Western Sandpiper

Bayland data from the Diked Baylands Wildlife Study (DBWS),1982-1989 (USFWS, *in prep*.).

the in fall, 3,400 in the winter, and possibly up to 17,000 in the spring.

North Bay - Sixteen percent of the San Francisco Bay total were found in San Pablo Bay (north of the Richmond Bridge). The North Bay accounted for up to 30% of the Bay total on PRBO counts.

Central Bay - Up to 30% of the Bay total for western sandpipers were found between the Richmond and San Mateo bridges on PRBO counts.

South Bay - Up to 79% of the Bay total were found south of the San Mateo Bridge on PRBO counts.

Historical Information

No information.

Population Trends

Rigorously estimated global population counts for western sandpiper are not available, but the West Coast population is estimated to be a few million birds (Page and Gill 1994). Population trends are currently unknown.

Habitat Use and Behavior

Based on a sample of 106 radio marked western sandpipers in South San Francisco Bay, birds showed seasonal differences in habitat preference both on local and regional scales (Warnock and Takekawa 1995). During winter at low tide, salt pond levees followed by mudflats

were most preferred, and salt marsh plains were used the least (Warnock and Takekawa 1995). At high tide, salt-pond levees were ranked as the most preferred habitat, followed by drained salt ponds, tidal salt ponds and seasonal wetlands, and salt marsh plains were the least preferred habitat. In spring at low tide, use of habitats was significantly different from the winter. Western sandpipers preferred tidal sloughs over tidal salt ponds, drained salt ponds, and mudflats. At high tide, they preferred drained salt ponds and seasonal wetlands. At both tides, salt marsh plains were the least preferred habitat. At low tide, in all seasons, the majority of western sandpipers occur on tidal flats.

Foraging - Western sandpipers feed mainly on invertebrates but occasionally will also feed on small fish and plant matter. They are tactile feeders that typically probe in the mud for prey. On the breeding grounds at the Yukon-Kuskokwim Delta, Alaska, common food items include Diptera larvae, adult Coleoptera, and arachnids depending on the time in the breeding season (Holmes 1972). On the winter grounds, common food items include amphipods, small bivalves, annelids, and insects (Stenzel et al. 1983, Wilson 1994). At San Francisco Bay, they have been found to feed on a diverse diet of amphipods, bivalves, polychaetes, ostracods, and gastrapods (Recher 1966). In salt ponds, they also feed on brine flies, insects, and seeds (Murie and Bruce 1935, Carpelan 1957, Anderson 1970). In the winter, birds have been found out on low tide mudflats during day and night (Warnock and Takekawa 1996).

Roosting - Roosting flocks sometimes number tens to thousands of individuals. Roosting sites tend to be barren to sparsely vegetated and include salt pond levees, dry to very shallow salt ponds, islands, beaches, diked baylands, etc.

Movement - Radio-tracking studies show species to be very limited in its movements within the Bay, but birds are known to move back and forth between Bolinas Lagoon and North San Francisco Bay during spring. Birds radio marked in South San Francisco Bay were not found outside the South Bay despite extensive search efforts in surrounding areas; birds typically move between Bay mudflats at low tide to salt pond roost areas at high tide regardless of time of day (Warnock and Takekawa 1996).

Conservation and Management

Contaminant Risks - Due to their small home ranges within the Bay, there is an increased potential for repeated exposure to environmental contaminants from industrial and municipal discharge (Warnock and Takekawa 1996).

Disturbance - Feeding and roosting flocks take flight in response to hunting raptors, sudden loud noises, and close approach by humans, pets, jet skies, and boats.

Introduced Species - Introduced invertebrates such as *Potamocorbula amurensis* (Nichols et al. 1990) could significantly influence the distribution and abundance of western sandpipers within the Bay.

Recommendations

The dynamics of the active salt industry provide a varied habitat for these small shorebirds. They need plenty of intertidal foraging habitat at low tide, and supertidal roosting and foraging areas at high tide. Seasonal wetlands, diked wetlands, muted tidal wetlands and salt ponds provide these supertidal functions. Salt ponds, especially when drained, provide habitat for huge numbers of birds. Any kind of habitat with muted tidal flow and less than 50% vegetative cover is important foraging habitat. Allowing these sites to become revegetated will likely negatively affect western sandpipers. Farmed and grazed baylands are crucial in extreme events such as severe winter storms or unusually high bird numbers, but an increase in this kind of habitat should not be at the expense of marsh habitat. Any expansion of tidal or supertidal habitats should not be done at the expense of intertidal mudflat habitat, which remains the most important feeding area for these birds.

To support the western sandpiper, the current acreage of tidal marsh should be increased. Mid-tidal and low tidal marsh should have no more than 60-70% vegetative cover. The current acreages of agricultural baylands, intertidal flat, treatment pond, and mid- and high salinity salt ponds should be maintained. Lagoons are important during low tide, and the acreage should be increased. Current acreages of low salinity salt pond and tidal reaches in streams should be increased. These general recommendations apply throughout the subregions.

Suisun - General recommendations given above.

North Bay - Areas of importance in the North Bay include all areas of intertidal flat, the exposed banks of Sonoma Creek and Napa and Petaluma rivers, tidal marsh channels, drained and shallow salt ponds, salt crystallizers, and Ponds 1A, 2A, and 4A. The general recommendations given above also apply to this subregion.

Central Bay - Areas of importance in the Central Bay include all areas of intertidal flat, roosting islands, and the Hayward marshes. The general recommendations given above also apply to this subregion.

South Bay - Areas of importance in the South Bay include all of the salt ponds (especially when drained), intertidal areas, seasonal wetlands, levee roost sites, diked marsh, and duck clubs. Particular locations include the Knapp property; Mowry, Newark, and Coyote sloughs; the upland marsh of tract 102 marshes, the Alviso Ponds, and Ponds RSF 1 and RSF 2. The general recommendations given above also apply to this subregion.

Research Needs

Currently, we have a poor understanding of where migrants that pass through San Francisco Bay in the spring are coming from, as well as where southward moving birds are going. The use of salt ponds by western sandpipers ought to be examined in more detail, as well as how invasive invertebrate species impact the distribution of western sandpipers within the Bay. The impact of revegetation of reclaimed salt ponds on western sandpipers using the ponds should be studied.

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Long-Billed Dowitcher

Limnodromus scolopaceus

John Y. Takekawa
Sarah E. Warnock

Introduction

The San Francisco Estuary supports large wintering populations of the long-billed dowitcher numbering in the low tens of thousands. More than most other abundant shorebirds, this species concentrates in fresh and brackish water wetlands. The key habitat for this bird is managed wetlands. It associates with dunlin (*Calidris alpina*), greater and lesser yellowlegs *(Tringa melanoleuca* and *T. flavipes*), black-necked stilt (*Himantopus mexicanus*), and American avocet (*Recurvirostra americana*), which also use these habitats.

Description

The long-billed dowitcher is a medium-sized shorebird (28-32 cm) with short legs and a long snipe-like bill (5.7-7.6 cm). In breeding plumage, long-billed dowitchers have cinnamon underparts with bars of black on the sides of the breast and flanks; a white wedge on the rump; black, buff, and white feathers above; and dull olive legs (Hayman et al. 1986). Although difficult to distinguish from the similar-looking short-billed dowitcher (*L. griseus*), it was identified as a separate species on the basis of morphological (Pitelka 1950) and genetic data indicating their relatively large congeneric divergence (Avise and Zink 1988). About 15% of the long-billed dowitchers are separable from short-billed dowitchers by a bill more than two times longer than the head (Richards 1988), but more consistent characteristics distinguishing the species include the "keek" vs. the "tu-tu-tu" call (Miller et al. 1984), white tail bars narrower than or equal in width to the dark tail bars, darker unspeckled throat and breast sharply distinct from underparts, foreneck densely spotted, center of breast barred, and belly lightly spotted (Wilds and Newlon 1983). Juveniles are distinguished by the buff appearance of their underparts and a grayer head and neck with narrow rusty fringes on their coverts.

Courtesy USGS/NBS

Breeding Biology - Long-billed dowitchers do not breed in the San Francisco Bay Area. They are arctic breeders that nest in grassy or sedgy marshes, or near small lakes (Hayman et al. 1986). They arrive during late April and May, and their breeding displays include low-level hovering flights and a distinctive "pee-ter-wee-too" call. They defend comparatively small territories, and nest in small clumps of low sedges, in mounds of moss and sedge, or on the ground. They lay four eggs (olive with many elongated spots), and both sexes incubate the nest for the 20-21 day incubation.

Migration Ecology - Females form postbreeding flocks as early as late June, while males depart their breeding areas in late July or early August. Juveniles migrate 1-2 months later (Campbell et al. 1990). They peak in autumn migration in British Columbia during September and October (Campbell et al. 1990). The long-billed dowitchers are generally 5-6 weeks behind the short-billed dowitchers during migration. Long-billed dowitchers generally migrate in smaller flocks than short-billed dowitchers. Flocks of 10-100 birds are commonly observed (Campbell et al. 1990). They migrate southeast to the Atlantic Coast and along the Pacific Coast or through the midcontinent. Groups of more than 30,000 have been counted at Malheur National Wildlife Refuge in interior Oregon (Gilligan et al. 1994). Their peak spring migration lasts from late March to mid-May, and they are rare east of the Mississippi River. They are seen in Oregon during late February and early March (Gilligan et al. 1994). They are rare migrants to Japan and Europe and are vagrant to Nova Scotia, Bali, Brunei, and Thailand.

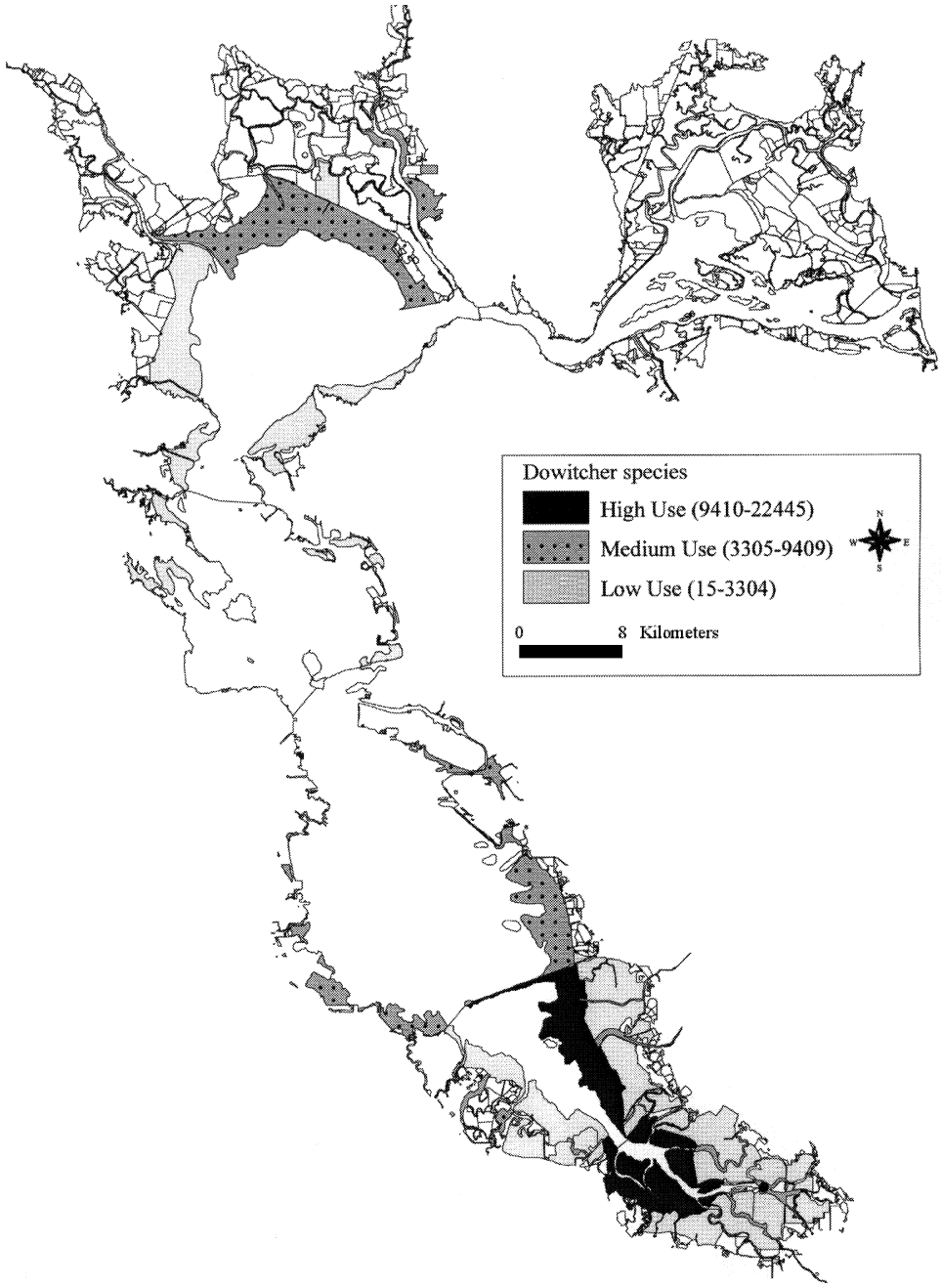
Wintering Ecology - Adult long-billed dowitchers begin arriving at Point Reyes, Marin County, California in July (Shuford et al. 1989), while juveniles arrive in mid-September. They winter in the southern United States and in Central America, as far south as Panama (Hayman et al. 1986). Those observed on inland areas in California are usually long-billed dowitchers (Cogswell 1977), but both species are found in coastal areas. They disappear during rainy periods on the coast, perhaps to the Central Valley (Shuford et al. 1989, Shuford et al. 1998).

Distribution and Abundance

North America - Long-billed dowitchers breed in coastal northeast Siberia, western and northern Alaska, the northwest MacKenzie River Delta (Cogswell 1977), and the Northern Yukon (Richards 1988). They winter in northwest and north central California, western Nevada, southern Arizona, and east to South Carolina and Florida, as far south as Guatemala and Panama, and as

Figure 6.17 Maximum Counts of Dowitcher Species

Data from PRBO Pacific Flyway Project, 1988-1992. Unpublished data (data from Suisun not presented).



far north as Washington State. They generally winter farther north than the short-billed dowitcher.

Pacific Coast - Long-billed dowitchers are found in both coastal and interior regions, including the Central Valley and in California lakes. Few birds are known to migrate along the western Pacific, but the San Francisco Bay Estuary is used during both migration and the winter. Estuaries in Sinaloa, Mexico also include large populations of this species (Engilis et al. 1998).

Suisun - Point Reyes Bird Observatory (PRBO) recorded up to 11,200 dowitchers in August, 6,000 in November, and 7,900 in April. This includes both *Limnodromous* species, but collections in San Francisco Bay (Takekawa and Warnock, unpubl. data) suggest most are long-billed dowitchers (**Figures 6.17** and **6.18**)

North Bay - Present, common.
Central Bay - Present, low abundance.
South Bay - Present, common.

Historical Information

There was a decline in numbers of dowitchers in eastern North America and California in the late 1880s and early 1900s because of hunting (Page and Gill 1994), until the passage of the Migratory Bird Treaty Act of 1918. The size of the populations have likely followed the abundance of mudflat habitats with benthic invertebrate prey, and this species may have benefitted by the development of salt evaporation ponds which provided high tide roost sites.

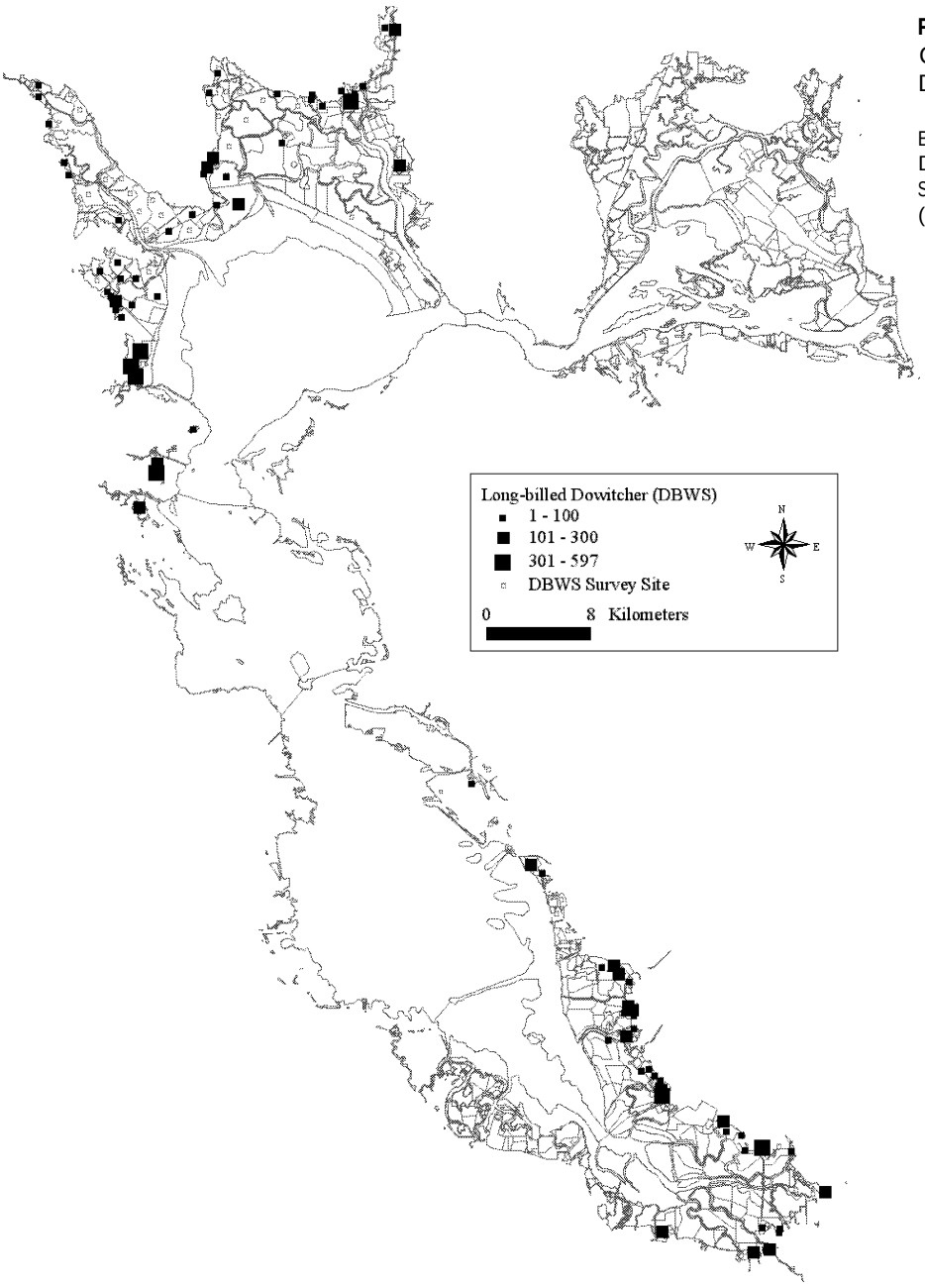


Figure 6.18 Maximum Counts of Long-billed Dowitcher

Bayland data from the Diked Baylands Wildlife Study (DBWS),1982-1989 (USFWS, *in prep.*).

Population Trends

In Florida, there has been an upward trend in recent years (Stevenson and Anderson 1994), but it is not known whether this reflects shifting populations or true population increases. No information is reported about the long-term population trends of the West Coast.

Habitat Use and Behavior

Long-billed dowitchers prefer freshwater habitats over brackish and intertidal areas (Campbell et al. 1990, Cogwell 1977, Pitelka 1950, Takekawa and Warnock *in press*). They use seasonal wetlands, flooded fields, reservoir edges, sewage lagoons, small ponds, lake and pond muddy shores, river banks, and sewage ponds (Campbell et al. 1990). They use intertidal flats for foraging and roosting, and roost on offshore rocks and islands (Campbell et al. 1990). At Nelson Lagoon, Alaska, long-billed dowitchers were found in muddier areas than short-billed dowitchers, which were found in sandier areas (Gill and Jorgenson 1979), but in Bolinas Lagoon, California, they were found in areas of moderately to well-sorted fine sand (Page et al. 1979). Flight surveys in the Central Valley of California found 66% of dowitchers in managed wetlands, 28% in agricultural lands, 3% in sewage and evaporation ponds, and 3% in other habitats (Shuford et al. 1993).

On the East Coast, they primarily use freshwater habitats, especially impoundments, salt pans (Veit and

Petersen 1993), or shallow impounded waters with scant vegetation (Tomkins 1961). They are most commonly found on "barrow-pit habitats" of soft dredge material in the Midwest, usually disturbed sites, often successional areas with short life spans (Tomkins 1961).

Foraging - Long-billed dowitchers are probing feeders on muddy substrates. Sand may reduce the success in prey capture or detection in comparison to muddy sites (Quammen 1982). They feed with exploratory jabs (depth 1/3 bill length) and acquire prey with prolonged and vigorous probing (depth to bill length) (Burton 1972) with 99% of their foraging in the sediment (Young 1989). The appearance of their foraging has been described as "sewing-machine" activity (Richards 1988). They commonly forage in salt water during migration (Cogswell 1977), but they are most commonly reported as associated with freshwater wetlands. They often forage in water up to their belly, and were found in depths of 2-8 cm in the Central Valley, California (Elphick and Oring 1998), 4-5 cm on South Island, South Carolina (Weber and Haig 1996), and 0-16 cm at Playa Lakes of Texas (Davis and Smith, 1998). On Seward Peninsula, Alaska, dowitchers are often found in salt grass meadow (Kessel 1989). In pastures along coastal California, dowitcher abundance is negatively correlated with vegetation height (Colwell and Dodd 1995). Their time-activity budget includes 79.6% feeding, 17.4% resting or preening, and 1.9% alert (Young 1989). Their breeding area diet includes meltwater pool insects, seeds, moss, and cranefly larvae, while migration and wintering diets include midge and fly larvae, worms, and burrowing crustaceans.

Roosting - Long-billed dowitchers probably roost in shallow water or on barren to sparsely vegetated islands and levees. They have also been seen roosting in salt marsh (G. Page, pers. comm.). Roosting flocks sometimes exceed 1,000 birds. They commonly use intertidal flats for foraging and roosting, and roost on offshore rocks and islands (Campbell et al. 1990).

Movement - Long-billed dowitchers generally follow a pattern of feeding on intertidal flats during low tide and roosting in adjacent wetlands or uplands during high tides.

Conservation and Management

Contaminant Risks - Pesticide and other contaminant levels are available for dowitchers, but interpretation of results are difficult since no experimental work on the effects of these toxins on either breeding or migrating and wintering birds is available. Compared with birds in Texas, dowitchers collected at San Francisco Bay had higher selenium levels and elevated aluminum levels (C. Hui, J.Y. Takekawa, and S.E. Warnock, unpubl. data).

Disturbance - Long-billed dowitchers feed in intertidal flats and roost on nearby uplands or shallow wetlands. They are likely to be disturbed regularly by raptors, loud noises, and close approach by humans and their pets. Page and Whitacre (1975) determined that sixteen percent of dowitchers wintering at Bolinas Lagoon, California were killed by raptors.

Recommendations

Information suggests that these birds prefer fresher water habitats over brackish and intertidal habitats. Seasonal wetlands and freshwater ponds are therefore more important to this species. These species are commonly found on soft, dredged-material habitats or disturbed sites.

Unvegetated levees and islets, pans, and seasonal and perennial ponds are important roosting habitat. Mudflats, pans, and seasonal and perennial ponds are important for feeding. General regional goals to support dowitchers include increasing mid- and high tidal marsh for roosting, maintaining the current acreage of intertidal flat and salt pond, maintaining the current acreage of agricultural baylands (or increasing the areal extent of seasonal wetlands on a smaller area), and increasing the acreage of diked and managed marsh.

Suisun - Within Suisun, these birds are found primarily in managed marshes, but the timing and numbers are not well known. The goals for Suisun should include maintaining current acreages of muted tidal marsh and intertidal flat, and increasing mid-tidal marsh, diked marsh, and managed marsh to increase shallow water habitat.

North Bay - Seasonal wetlands and freshwater ponds are more important to this species in the North Bay. There is limited information available on the use of North Bay salt ponds, and also farmed and grazed bayland. Ponds 1A and 1AN, and all of the former Cargill salt ponds are critical habitat. Other important areas include the marshes of the Lower Napa River, mudflats of San Pablo Bay, and the area east of Cabana Isle. Current acreages of muted tidal marsh and intertidal flat should be maintained, and shallow managed marsh, mid-tidal marsh, and diked marsh should be increased.

Central Bay - Within the Central Bay there are limited areas of use, and unknown roost areas. The general regional goals above apply wherever applicable.

South Bay - The South Bay is the most important area in the Estuary for the long-billed dowitcher. Particular areas of importance include Ponds R1, R2, SF1, and SF2; all low salinity salt ponds; salt ponds and mudflats south of the San Mateo Bridge, and the Knapp property. The current acreages of low and mid-salinity salt ponds, muted tidal marsh, and intertidal mudflat should be maintained; and acreages of mid-tidal marsh, shallow managed marsh; and diked marsh should be increased.

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Wilson's Phalarope

Phalaropus tricolor

Janet T. Hanson

Introduction

Wilson's phalarope is representative of the group of shorebird species concentrated in salt ponds, including red-necked phalarope, American avocet, and black-necked stilt. Phalaropes forage by swimming in tight circles, or "spinning" on the ponds' surface to stir up prey items, a difference that sets them apart from other shorebirds. Wilson's and red-necked phalaropes are present on the Bay during fall and spring migration.

No precise information exists on local numbers of these species in the early part of this century, but current surveys suggest that they increased significantly with the development of the salt pond system, which they utilize as both foraging and roosting habitat. In addition, stilts and avocets are present year-round and make use of the levees and islands in the pond system for breeding habitat. Wilson's phalarope has suffered loss of breeding habitat in the inland wetlands it favors. On a global scale, this species appears to be declining in numbers.

Description

Wilson's phalarope is a medium-sized (22-24 cm) shorebird with mostly white plumage, short legs and a mid-length straight bill. This species is characterized by its reverse sexual dimorphism: the female is larger and more colorful in breeding plumage. In non-breeding plumage, both sexes have gray upperparts, pure white underparts, and yellow legs. There is a white superciliary line with a strong gray post-ocular line above. In breeding plumage, the females' crown and nape are pale gray. A strong black stripe runs from the bill, through the eye and down the neck. The breast is cinnamon or rusty color with a white belly and the legs are black. The breeding plumage of the male is a duller version of female (Colwell and Jehl 1994).

Courtesy USGS/NBS

Breeding Biology - Wilson's phalarope breeds on seasonal wetlands and freshwater marshes in the North American grasslands and prairies. This species is one of 13 species of shorebirds reported to practice polyandry. Females arrive first on the breeding grounds in late April-early May, followed by mixed flocks (Bent 1927). Several females often court a single male. Eggs are laid by mid-May to early June; a single nest typically contains four camouflaged eggs, buff colored with brown blotching. The male incubates while the female defends the territory. Incubation lasts approximately 23 days. The male broods and cares for the precocial young until they fledge.

Migration Ecology - Females depart as early as mid-June, followed by males and then juveniles in July (Colwell and Jehl 1994). Adults and juveniles congregate mostly on large interior alkali lakes, including Lake Abert, Oregon, Great Salt Lake, Utah, and Mono Lake, California to molt into basic plumage and accumulate fat for southbound migration (Reed et al. 1994). Smaller numbers stop on the West Coast, with San Francisco Bay's salt pond system being the major coastal staging area (Colwell and Jehl 1994). Individuals are rarely seen away from these staging areas. By mid-September, the birds have headed south to feeding grounds in South America, apparently flying non-stop from the central Pacific Coast and Great Basin staging areas to wintering grounds in South America.

Wintering Ecology - Wilson's phalaropes winter on saline lakes and freshwater marshes in southern South America, mainly in the Andean highlands of Bolivia, Peru, Chile, and Argentina (Jehl 1988).

Distribution and Abundance

North America - During breeding season, this species is found in the shallow ephemeral wetlands of interior western North America. Fall populations are estimated at 1.5 million birds on major staging areas (Jehl 1988).

Pacific Coast - The only major coastal site is San Francisco's salt pond system in the summer months.

San Francisco Bay - Wilson's phalaropes are seen almost entirely on the South Bay's salt ponds and their islands, primarily from June to August (Jurek 1973; Swarth et al. 1982, Harvey et al. 1988). Peak numbers occur in July.

Standard spring and fall shorebird surveys have fallen either too early or too late to capture peak numbers of Wilson's phalaropes. Point Reyes Bird Observatory's (PRBO) baywide counts detected maximums of 1,642 in the fall, zero in the winter, and 213 in the spring.

Suisun - PRBO fall count: 225; not seen on winter or spring counts.

North Bay - Not seen on PRBO's spring 1988 count, but see **Figure 6.19**.

Central Bay - Not seen on PRBO's spring 1988 count, but see **Figure 6.19**.

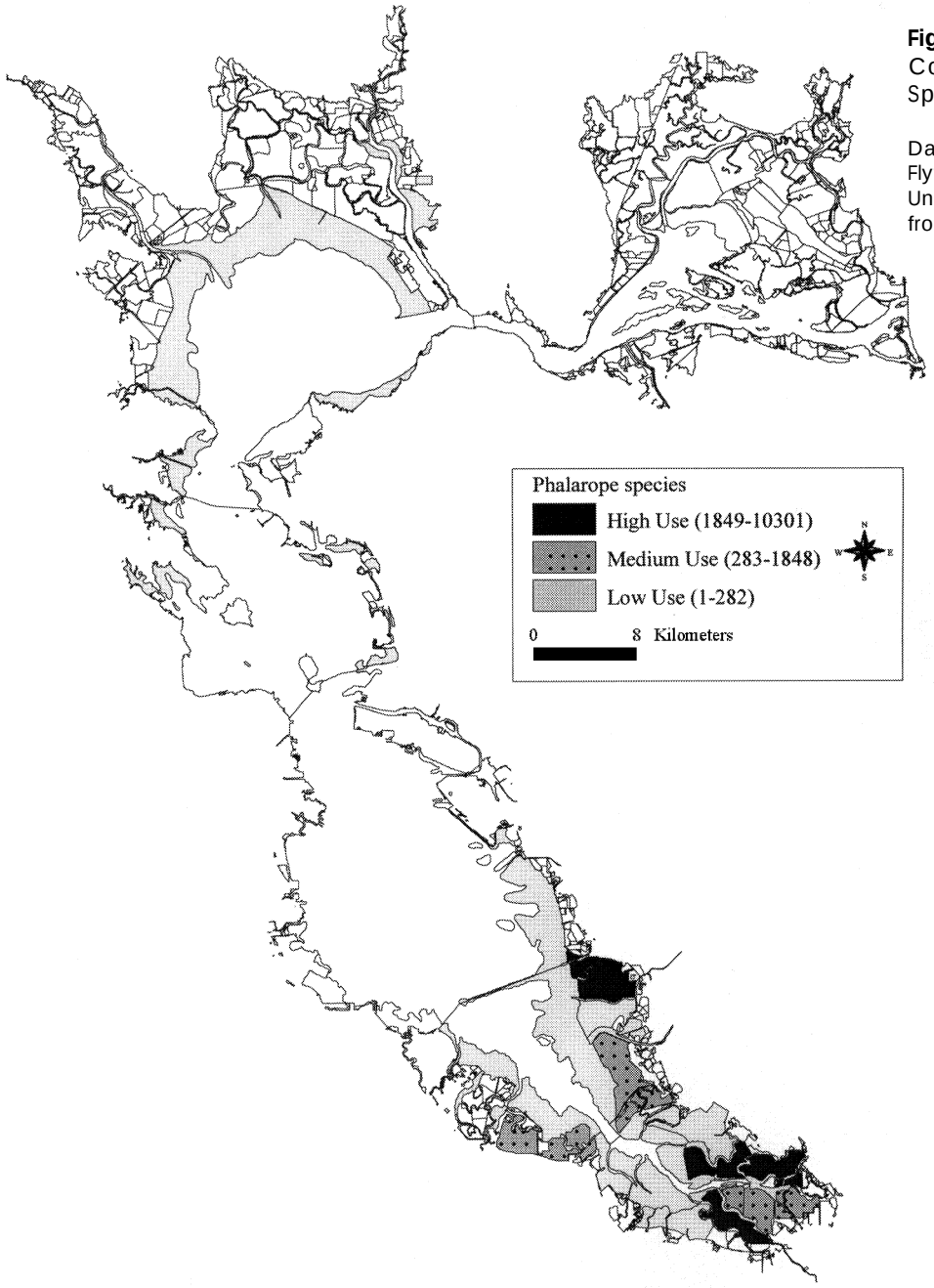

Figure 6.19 Maximum Counts of Phalarope Species

Data from PRBO Pacific Flyway Project, 1988-1992. Unpublished data (data from Suisun not presented).

South Bay - PRBO spring count: 213. Reportedly can reach a fall peak of 40,000 birds (Jehl 1988; see **Figures 6.19** and **6.20**).

Historical Information

No information.

Population Trends

It has been suggested that the global population of Wilson's phalaropes has declined due to loss of prairie wetland habitat in their breeding range (Dahl and Johnson 1991; Page and Gill 1994).

Habitat Use and Behavior

During spring high tide censuses in south San Francisco Bay, Wilson's phalaropes were most commonly found on the salt ponds and on islands in the salt ponds; they have also been observed in freshwater treatment ponds (Hanson and Kopec 1994). Harvey, et al. (1988) documented a preference for high salinity (75-200 ppt) ponds, probably due to the invertebrates that are present in more abundance at these higher salinities.

Foraging - Wilson's phalaropes forage most commonly on open water habitats, either by "spinning," or by standing in shallow water and lunging, or by scything like an avocet. Unlike other phalarope species present

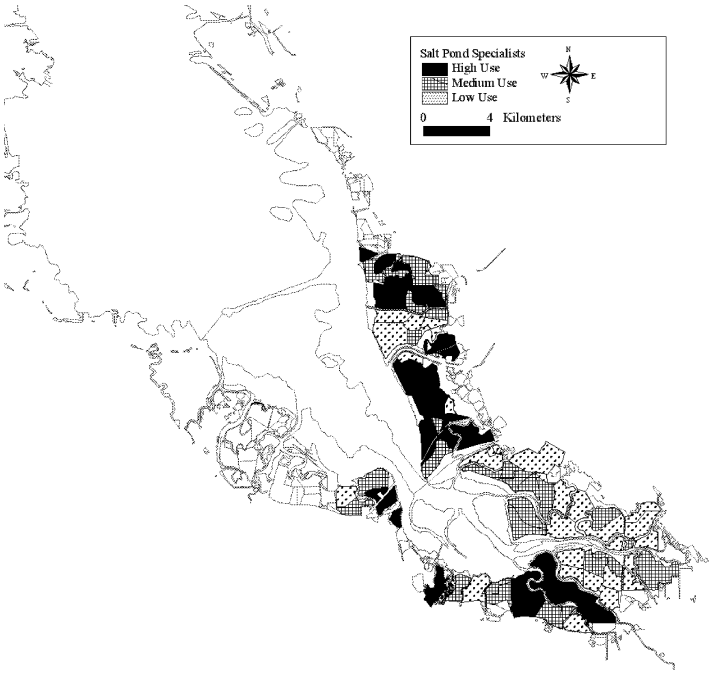

Figure 6.20 Relative Use of Salt Ponds by American Avocet, Snowy Plover, Black-necked Stilt, and Phalaropes

Data from PRBO Pacific Flyway Project, 1988-1992. Unpublished data.

on the Bay, they also probe mudflats; foraging strategy is probably dictated by prey availability. Prey items found in five birds collected on South San Francisco Bay salt ponds included water-boatmen, pupae of brine flies, brine shrimp, seed of round stem bulrush, and larvae of brine flies and other insects (Anderson 1970).

Roosting - Wilson's phalaropes roost at night on open water. In the San Francisco Bay, they roost nocturnally on the salt ponds. On inland lakes, they also form diurnal roosting flocks on shore or on boulders (Jehl 1988). They may possibly use islands or levees in the Bay's salt pond system for this purpose but this has not been documented.

Movement - There is no recorded observation of local movements of Wilson's phalaropes. Because this species has been observed foraging on mudflats in other locations, they may be moving from the ponds to exposed mud during low tides.

Conservation and Management

Wilson's phalarope is threatened by loss of its breeding habitat, the seasonal wetlands of the interior. Many of its post-breeding locations (the salt pond system, Mono Lake, the Salton Sea, and Great Salt Lake) are undergoing change, some created by human management and some outside of that control. Threats to wintering habitat in South America are poorly understood.

Recommendations

The South Bay is the area of greatest importance to this species, and salt ponds and treatment ponds, both of which are used for foraging and roosting, are the most important habitat elements.

Wilson's phalaropes use the San Francisco Bay most heavily for two weeks in late July during their post-breeding migration, the time when they are most dependent on the Bay. Most bird surveys do not capture the true numbers of Wilson's phalaropes in the Bay because of the short duration of their visit, but the importance of the Bay to the population should not be underestimated. Wetlands could possibly be managed for this species if more was known about its requirements. Maintain medium to high salinity ponds, especially in June-August and particularly in the South Bay, where mild climatic conditions may be favored by shorebirds in general.

Suisun - Wilson's phalaropes have only been reported in small numbers from the Suisun subregion, but this may be due to the timing and nature of bird surveys in that area. Maintain or increase the current acreage of managed wetlands to support this species.

North Bay - Though pond habitat exists in the North Bay subregion, Wilson's phalaropes have not been seen. This may be due to the timing of the bird surveys, however. Maintain some of the existing salt ponds to support this species.

Central Bay - Wilson's phalaropes have not been seen in the Central Bay subregion. Promote inclusion of ponds and managed wetlands in any bayland restoration projects that may be undertaken in this highly developed area.

South Bay - Maintain the current acreages of low, mid, and high salinity salt ponds, and of treatment ponds. Particularly important within this region are the

Hayward area sewage treatment ponds; Turk Island area ponds (particularly 1C-6C); Coyote Hills Ponds 2A-4A; Coyote Creek waterbird pond; Sunnyvale sewage treatment ponds; Mountain View Pond A3N; and Ravenswood Ponds 2 and 4A.

Many more ponds in the South Bay subregion have the potential for use by Wilson's phalarope (Dumbarton; Mowry ponds; Alviso ponds; Ponds A3E and A3W in Mountain View), but birds have not been seen on these ponds yet. This may be due to the timing of the surveys.

Research Needs

Future research should investigate optimum salinities for the invertebrate prey base this species is dependent on.

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Waterfowl and Shorebirds of the San Francisco Bay Estuary

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Gary W. Page
Janice M. Alexander
Dennis R. Becker

Introduction

Waterfowl and shorebirds are characterized by their mobility and strong dependence on aquatic and wetland habitats. The San Francisco Bay Estuary is renown as a major North American refuge for many species of waterfowl and shorebirds during their migration and wintering (August through April) periods, and it provides breeding habitat during the summer for a few species (e.g., mallard *Anas platyrhynchos*, black-necked stilt *Himantopus mexicanus*, snowy plover *Charadrius alexandrinus nivosus*). The Estuary is recognized as a Western Hemisphere Shorebird Reserve Network site of international importance for more than a million shorebirds in migration (Kjelmyr et al. 1991; PRBO, unpubl. rept.) and as the winter home for more than 50% of the diving ducks in the Pacific Flyway (Accurso 1992) with one of the largest wintering populations of canvasbacks (*Aythya valisineria*) in North America.

Current populations of shorebird and waterfowl species in the Estuary are a reflection of human alterations (see Nichols et al. 1986) that have resulted in increased numbers of some species while others have decreased. We do not know how many distinct populations depend on the habitats of this ecosystem and contribute to diversity and stability of continental populations. For example, northern pintails (*Anas acuta*) in the South Bay have little interchange with birds in the Central Valley, and they may represent a distinct subpopulation (M. Miller, pers. comm.). Western sandpipers (*Calidris mauri*) show strong site fidelity to small areas in the South Bay and do not leave that subregion during the winter (Warnock and Takekawa 1996).

Loss of more than 90% of the wetlands in the past 150 years has greatly altered the ecosystem, resulting in

the proposed listing or protection of more than one hundred species, many associated with tidal salt marsh habitats. Many projects to rehabilitate or restore wetlands, especially tidal salt marshes, have been proposed to benefit listed species in the Estuary. For example, the San Francisco International Airport recently proposed restoration of salt ponds in the South Bay, used heavily by both waterfowl and shorebirds, to tidal marsh as mitigation for runway expansion. However, results of such wetland restoration efforts are highly variable (Race 1985), and the efforts to complete successful salt marsh restorations for certain species may come at the expense of shorebird and waterfowl populations that use the existing habitats, including salt evaporation ponds. Critical habitats for waterfowl and shorebirds include tidal flats; sparsely vegetated wetland elements (levees, islets, beaches); managed wetlands; large, persistent seasonal ponds with lots of open water; and active and inactive salt evaporation ponds.

Unfortunately, we lack specific information relating abundance of current populations to the amount of their habitats. We are unable to predict how reduction of present wetland habitat used by these species may affect their populations. Thus, we recommend care in implementing large-scale changes and encourage further study of critical habitats and better delineation of the regional populations present in the ecosystem. We also offer several principles to guide management efforts while considering the habitat needs of waterfowl and shorebirds (Goals Project 1999: Appendix C), and emphasize that these species are unlikely to benefit from tidal marsh conversions when the conversion is from another wetland type. Finally, we support an ultimate goal of accepting no net loss of shorebird and waterfowl resources and populations in the ecosystem while conducting restoration or enhancement projects.

Waterfowl

The San Francisco Bay region is identified as one of the 34 waterfowl habitat areas of major concern in the North American Waterfowl Management Plan (USFWS 1989). More than 30 species of waterfowl are found in the San Francisco Bay ecosystem. These species are commonly divided into dabbling ducks, which feed at the surface or in shallow water to the depth of their body length, diving ducks, which forage underwater, and swans and geese, which feed on plants by grubbing in sediments of wetlands or fields. Mid-winter waterfowl surveys (USFWS, unpubl. data) of the San Francisco Bay and Delta include more than 700,000 waterfowl, and surveys of the open bays and salt ponds (Accurso 1992) include more than 300,000 individuals, a 25% decrease from the earliest surveys in the 1950s. In 1988-1990, dabbling ducks comprised up to 57,000 of the waterfowl in the open bays and ponds of the Estuary, while diving ducks comprised up to 220,000 of the total. For this review, we selected six species as representative taxa of the waterfowl and the habitats they use in the ecosystem.

Dabbling ducks represent 8-30% of total waterfowl numbers. Northern pintail (*Anas acuta*) use a wide variety of habitats, including managed marsh, seasonal wetlands, open bay, and salt ponds (see *Northern Pintail profile*). They were historically the most common dabbling ducks in the ecosystem, but recent population declines of this species have been severe (90% decrease in Suisun Marsh). Pintails in the South Bay subregion have little interchange with birds in the Central Valley (M. Miller, pers. comm.) and may comprise a distinct population with a unique breeding area. Mallards (*Anas platyrhynchos*) have large economic and recreational importance as a hunted species, and are the most abundant dabbling duck in diked baylands, and especially seasonal wetlands, low salinity salt ponds, and managed marshes of the San Pablo and South Bay subregions.

However, the Estuary is most recognized for the large populations of diving ducks, both bay ducks and sea ducks. Canvasbacks (*Aythya valisneria*) are bay ducks that were identified as a species of special concern because of declining numbers, but the Estuary still supports the largest population of canvasbacks in the Pacific Flyway and represents one of the largest wintering areas in North America (see *Canvasback profile*). Protecting their open bay habitats was part of the reason that the San Pablo Bay National Wildlife Refuge was established in the 1970s. They traditionally foraged on aquatic plants in mouths of rivers or channels, but now primarily consume nonindigenous mollusks in open bays or salt ponds. The Estuary also is a major wintering area for up to 140,000 greater and lesser scaup (*A. marila* and *A. affinis*), a species we associate with canvasbacks that comprises more than 40% of the waterfowl in the open bays and salt ponds. However, scaup have suffered an unexplained continental decline in the past decade. Smaller diving ducks of the Estuary include the ruddy duck (*Oxyura jaimaicensis*) and bufflehead (*Bucephala albeola*), which use a variety of managed marsh areas and

Calif. Dept. Fish and Game

Mallards have significant economic and recreational importance as a hunted species. Hunting proponents lead many efforts to preserve and restore waterfowl habitat.

salt ponds in the baylands. The wintering population of ruddy ducks is one of the largest in North America (see *Ruddy Duck profile*), and as many as 7,000 bufflehead also are found in the Estuary.

Many sea ducks have declining populations which resulted in organization of a Sea Duck Joint Venture under the North American Waterfowl Management Plan. Sea ducks use open-water marine habitats, and surf scoters (*Melanitta perspicillata*) are one of the least studied of the North American waterfowl (see *Surf Scoter profile*). San Francisco Bay appears to be the most important inshore habitat for this species in the eastern Pacific, south of the Straits of Georgia and Puget Sound. Surf scoters are the second most numerous species in the ecosystem, with estimates as high as 73,000 birds in 1991 (Trost 1997).

Geese and swans are of economic and recreational importance, as four of the six members of this group are hunted, and overpopulation of geese may cause large urban and agricultural damage. These species are associated primarily with managed wetlands and agricultural lands in the region. Tule geese (*Anser albifrons gambeli*) were chosen to represent geese and swans, because they are recognized as one of the smallest goose populations in the world (> 7,000), and Suisun Marsh is one of the few wintering areas where it is found. Formerly, geese were present in larger numbers in the San Francisco Bay Estuary, but they are now down to a remnant few, primarily in Suisun Marsh. A population of what was perhaps a few hundred greater white-fronted geese (and possibly the tule subspecies) in the North Bay now number less than 20 individuals (L. Allen, pers. comm.), and thousands of lesser snow geese (*Anser caerulescens caerulescens*), which were once reported in the South Bay, no longer occur in the region.

Waterfowl Habitat Considerations

Salt Evaporation Ponds - In one of the only studies to examine wetland conversion effects on ducks, the body condition of mallards decreased significantly following loss of salt pans and fish ponds in Spain (Rodrigues and Fabiao 1997). Alternate roosting areas were 13 km farther from feeding areas, which may have resulted in higher energy costs for travel. Salt evaporation ponds supported 30-41% of the waterfowl in the San Francisco Bay Estuary, 9-14% in the former North Bay ponds, and 21-27% in the South Bay ponds (Accurso 1992). Many of the birds found in the Estuary during migration (September-October, March-April) were found in these areas. Up to 42,000 diving ducks have been counted in the North Bay ponds, including 30% of the ruddy ducks in the Estuary, 59% of the canvasbacks, and 38% of the bufflehead. As many as 15% of the dabbling ducks were also found in these ponds, including 19% of the northern pintail and 47% of the mallards. Eighty-three percent of waterfowl were found in 54% of the salt pond area with salinities of 20-93 ppt, with most birds preferring 20-33 ppt areas. Pond size explained much of the variation in counts, with less than 2% of the use on small ponds < 150 ha, and most diving duck use on ponds 200 to 550 ha.

South Bay salt ponds supported up to 76,000 or 27% of the Estuary's total waterfowl. This area provided the largest haven for ruddy ducks (up to 67% of the population), and supported 17% of the canvasbacks, 50% of the bufflehead, and up to 86% (47,000) of dabbling ducks, including the majority (90%) of northern shovelers. Waterfowl were concentrated in lower salinity (20-63 ppt) ponds, with few birds present in ponds above 154 ppt. Most waterfowl used ponds of moderate size, from 50 to 175 ha.

Open Bay Areas - Up to 50% or 140,000 of the diving ducks surveyed in the Estuary during the winter were counted in the North Bay subregion. Densities were as high as 653 birds/100 ha. The populations include up to 35% of the scoter, 26% of the canvasbacks, and 12% of the scaup. Most of the use was in water depths < 4 m, although much of the open bay area was less than 6 m. The Central Bay supported 17% of the waterfowl, or up to 53,000 birds including 20% of the diving ducks. This area was important for scoter (up to 50%), scaup (16%), and bufflehead (13%), but only 1% of the dabbling ducks. The South Bay supported 9-11% or 36,000 of the waterfowl in the Estuary, and was important for scaup (18%) and scoter (16%). The open waters of Suisun Bay supported only 12% of waterfowl in the Estuary, including up to 15% of the diving ducks (17% of scaup, 16% of scoter, and 16% of canvasbacks).

Shorebirds

Shorebirds are aquatic birds with cylindrical bills varying considerably in length and curvature, reflecting different foraging strategies. Among the 31 species encountered regularly on San Francisco Bay, a wide range of sizes is evident from the sparrow-sized least sandpiper (*Calidris minutill*a) to the duck-sized long-billed curlew (*Numenius americanus*). They feed primarily on invertebrates obtained on tidal flats, salt ponds, managed wetlands and other habitats. Most tidal flat specialists are found concentrated in the North and South bays (**Figure 6.21**; G. Page, unpubl. data). Recent survey information indicates that San Francisco Bay supports very high numbers of shorebirds of most species during migration and winter compared with other wetlands along the Pacific Coast of the United States (Page et al. 1999). San Francisco Bay has been recognized as a site of hemispheric importance to shorebirds by the Western Hemisphere Shorebird Reserve Network.

The Waterfowl and Shorebirds Focus Team selected seven "key" shorebird species as a basis for defin-

ing regional wetland habitat goals for shorebirds. The key shorebird species were selected based on their taxonomic grouping, population status, and habitat use (Goals Project 1999). The Pacific Coast population of western snowy plover was selected because it is federally listed as a threatened species, and about 10% of the listed population (over 100 pairs) has been recorded breeding in the Estuary, primarily in South Bay salt evaporation ponds (see *Snowy Plover profile*). The red knot (*Calidris canutus*) was selected because the Estuary is one of only three wetlands on the Pacific Coast supporting as many as several hundred wintering individuals, and they are found foraging in tidal flats of the Central and South bays and roosting in salt ponds.

The western sandpiper is the most abundant shorebird in the Estuary (see *Western Sandpiper profile*), and represents small sandpipers and plovers, while the marbled godwit (*Limosa fedoa*) was selected to represent large sandpipers and plovers. Tidal flats are the most important foraging habitat of all these species, and they roost at high tides in salt ponds, managed wetlands, seasonal wetlands, and other habitats above the high tide line. The long-billed dowitcher (*Limnodromous scolopaceus*) and its associates are singled out as potentially deriving more benefit from managed brackish water wetlands and seasonal wetlands than other shorebirds (see Takekawa and Warnock, in press). The black turnstone (*Arenaria melanocephala*) represents shorebirds that use gravel to rocky intertidal habitat (see *Black Turnstone profile*), although none of these rocky intertidal species are abundant in the Bay, numbering at most in the low hundreds.

The Wilson's phalarope (*Phalaropus tricolor*) was chosen to represent those shorebirds that, in addition to the snowy plover, are most dependent on the salt ponds for foraging habitat. These salt pond specialists are found patchily distributed (Figure 6.22; G Page, unpubl. data), especially in the South Bay salt ponds, depending on water level and salinity. Some members of this group, including the Wilson's and red-necked phalarope (*Phalaropus lobatus*), occur only during spring and fall migration, while the others, including black-necked stilt and American avocet (*Recurvirostra americana*), are resident and nest primarily in South Bay salt ponds.

Shorebird Habitat Considerations

Except for anecdotal information suggesting an increase by shorebird species using salt ponds as their primary foraging or breeding habitat, there are no consistent historic data on changes in abundance of shorebirds in the Estuary during the past 150 years when most human-induced habitat alterations have occurred. The most recent mapping of historic and current habitats by the San Francisco Estuary Institute (SFEI) indicates that tidal flats outboard of the salt marshes have increased in the North Bay and South Bay subregions, but that the total amount of tidal flat has decreased in all subregions, primarily due to loss of tidal flats along slough channels in salt marshes. Since the majority of the shorebirds in the Bay use tidal flats as their primary foraging habitat, the amount of foraging areas, and possibly the abundance of these species, may have decreased in the past 150 years, unless artificial salt ponds and managed wetlands have compensated for the tidal flat losses.

For the majority of shorebirds that forage primarily on tidal flats, conversion of salt ponds might be mitigated (by an unpredictable degree) by creating wide, gently-sloped tidal flats along large channels in restored tidal marsh. Tidal salt marsh and slough channels do not, however, provide high tide roosting habitat for most shorebird species, which require barren to sparsely vegetated sites above the high tide line. Thus, in projects where tidal marshes replace existing habitats, suitable roosting areas in reasonable proximity to tidal flats will need to be constructed to replace roosting areas that are lost.

For the salt pond specialists, substantial areas of salt pond habitat should be maintained in both the North Bay and South Bay subregions. If portions of the existing salt pond systems are converted to tidal marsh and managed salt ponds, it will not be feasible to set aside ponds with important shorebird habitat in a piecemeal fashion. Instead, smaller salt pond systems should be retained and activity managed to produce salinities and water depths most favorable to shorebirds and the other aquatic species targeted for protection. Low, wide, barren to sparsely-vegetated internal levees with fine scale topographic relief should be incorporated into the pond design as nesting and roosting substrate. In addition, salt marsh restoration efforts should attempt to recreate playas that occurred in historic salt marshes.

Since the success of marsh restoration efforts are likely to be highly unpredictable and the value of slough mudflats and salt marsh playa for shorebirds is not well understood, incorporation of these habitats into restored marshes should not be counted as replacement habitat for shorebirds. Further research must be undertaken to

Shorebirds on the mudflats at Charlston Slough, South San Francisco Bay

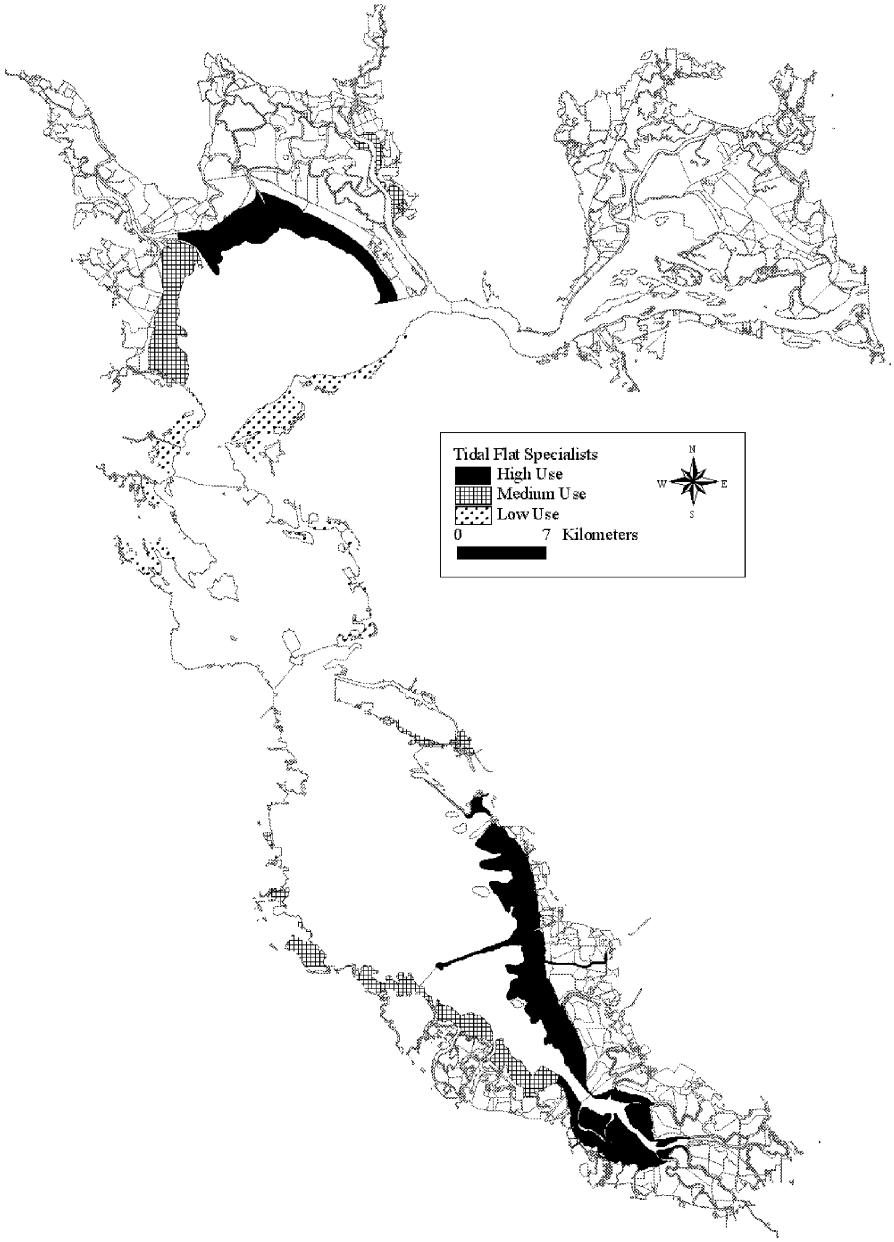

Figure 6.21 Relative Use (High, Medium, Low) of Different Mudflat Areas by Tidal Flat Specialists, as Indicated from the Proportion of Shorebirds Counted in Different Survey Areas

Data from PRBO Pacific Flyway Project, 1988-1992. Unpublished data.

estimate the amount of salt pond habitat that should be intensively managed for shorebirds and other target species. The maintenance of at least the current numbers of shorebirds relying extensively on salt pond habitat will require an adequate acreage of suitable ponds for 25,000 wintering American avocets, 5,000-7,000 wintering black-necked stilts, tens of thousands of migrating Wilson's and red-necked phalaropes in the fall, and 300 breeding snowy plovers.

General Recommendations for Waterfowl and Shorebirds

It is important to maintain existing populations of waterfowl and shorebirds in the Bay while increasing habitat for other species that are dependent on salt marsh. Increasing the acreage of salt marsh will come at the expense of other habitats, especially salt ponds and managed wetlands that are also important for waterfowl and shorebirds. Maintaining current shorebird and waterfowl populations will thus require increasing the carrying capacity of remaining salt ponds and managed wetlands or recreating their function in new locations.

Suisun - Although these wetlands are managed primarily for waterfowl habitat by private land owners, populations of one of the major target species, northern pintail, have decreased by as much as 90%. Thus, despite the best management efforts, populations of waterfowl in the Suisun Marsh have decreased. Any conversion of managed wetland habitats will result in a loss of waterfowl. Conversion of this area should proceed gradually to provide time to evaluate population changes and the effects of the loss of habitat. Conversion or loss of this habitat type must be offset by enhanced manage-

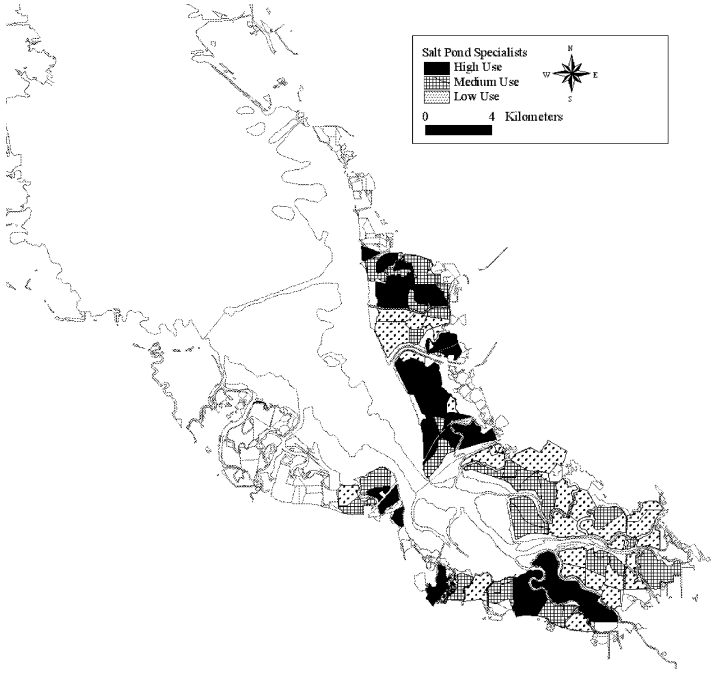

Figure 6.22 Relative Use (High, Medium, Low) of Different South Bay Salt Pond Areas by Salt Pond Specialists as Indicated from the Proportion of Shorebirds Counted in Different Survey Areas

Data from PRBO Pacific Flyway Project, 1988-1992. Unpublished data.

ment of existing areas or mitigation with alternative areas. Shorebirds are present in the tens of thousands. Management should be promoted to improve areas for their populations.

North Bay - The former salt evaporation ponds in this region are a critical area for waterfowl and shorebirds. Ongoing conversion should be linked to enhanced management of existing areas or mitigation. In this subregion, conversion of 50% of the former salt ponds may result in loss of 24% of the 42,000 waterfowl that are counted in these ponds (**Figure 6.23**; J. Takekawa, unpubl. data). Change in salt pond areas may already be resulting in reduction of waterfowl numbers (USFWS mid-winter surveys, unpubl. data). Thus, there is an immediate need to develop alternative managed marsh areas in this subregion. Although mudflat habitats seem abundant in the North Bay, shorebird roosting habitats may be limiting and should be increased.

Central Bay - This subregion is highly urbanized and is used least by both waterfowl and shorebirds. Any additional roosting habitat that can be protected from disturbance would be beneficial in maintaining or improving existing populations. Restoration of any large, shallow ponds would likely benefit waterfowl and shorebirds. Wetland rehabilitation in urban areas should be encouraged.

South Bay - The majority of the waterfowl and shorebirds in the South Bay use the salt evaporation ponds for roosting or feeding habitat during the winter. Conversion or loss of this habitat type must be offset by enhanced management of existing areas or mitigation with alternative areas, including created salt ponds, managed wetlands, and seasonal wetlands. For example, analysis of waterfowl survey data from 1988-1990 suggests that if 50% of the salt ponds are converted, 15% of the 76,000 waterfowl may be lost (**Figure 6.24**; J. Takekawa, unpubl. data). An increasing number of waterfowl would be displaced if more area was converted.

Although mudflat foraging habitat seems adequate, with salt pond conversion, suitable roosting habitat for shorebirds may become limiting. Little is known about how salt ponds and seasonal wetlands provide food for shorebirds and protected microclimate areas during adverse weather. Thus, we recommend not more than 50% or 15,000 acres of salt ponds in the South Bay be converted to other habitats without careful planning for habitat mitigation for shorebird and waterfowl populations. We also recommend an increase in seasonal wetlands as migration habitat and roosting areas.

Enhancing Tidal Marsh Restoration Projects for Waterfowl and Shorebirds

Waterfowl and shorebirds may use several elements in tidal salt marshes. As restoration or rehabilitation is undertaken, these elements should be provided when possible.

1. Larger channels with large mudflats are often used by shorebird and waterfowl species and should be encouraged in tidal marsh design.
2. Muted tidal areas provide temporal diversity which may provide good habitat, especially for diving ducks.
3. Unvegetated levees and islets with gradual slopes that are durable, and bare areas that remain unvegetated with limited management should be constructed as roosting sites.

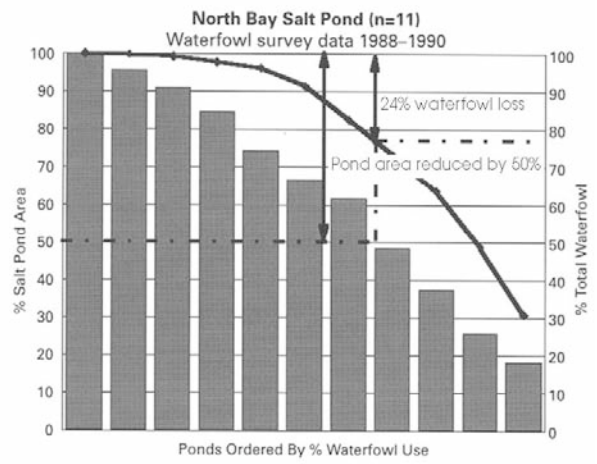

Figure 6.23 Waterfowl Use of Salt Ponds in the North Bay Ordered from Most to Least Waterfowl Use

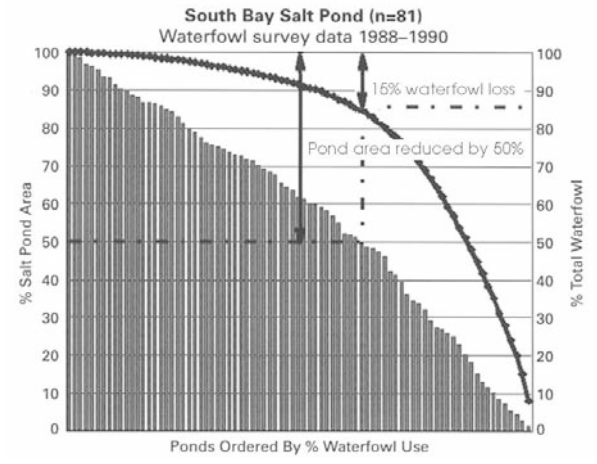

Figure 6.24 Waterfowl Use of Salt Ponds in the South Bay Ordered from Most to Least Waterfowl Use

4. A diverse mix of pans and ponds should be retained in marsh plains for high tide roosting and foraging areas.
5. Designs should be made to minimize disturbance by people, pets, and predators.
6. Surveys of waterfowl and shorebirds should be conducted prior to restoring areas to tidal salt marsh so losses may be evaluated and suitably mitigated.

Research Needs

Relationships among habitat change and change in populations of waterbirds have been studied in other estuaries (see Goss-Custard et al. 1997). We should learn from these efforts and develop a research program in the San Francisco Bay Estuary to examine questions raised during the Habitat Goals Project, including the following topics:

1. Determine the feasibility of designing ponds or systems from the existing salt evaporation ponds which can support the current populations of waterfowl and shorebirds.
2. Evaluate what constitutes a good roosting area for different species of shorebirds, including distance from feeding areas. Areas used within tidal salt marshes should be included.
3. Estimate the size and composition of shorebird populations in Suisun subregion.
4. Determine the importance of non-mudflat habitats such as salt ponds and seasonal wetlands as foraging areas, especially during inclement weather.
5. Examine seasonal wetland use and extent (not currently shown in the EcoAtlas), including diked farmland, grazed baylands, diked marsh, managed marsh, and ruderal baylands through wet and dry years.
6. Test differences in shorebird and waterfowl response to different actions in managed wetlands by measuring use-days and numbers.
7. Relate diving ducks use of wetlands by area size and water depth.
8. Quantify shorebird foraging and roosting in wetlands other than intertidal flats, including intertidal pans, low and medium salinity ponds, managed marsh, diked marsh, muted tidal, and seasonal ponds. Include factors such as tidal cycle, salinity, vegetation, and distance to intertidal flats.
9. Describe use of wetlands by salinity and prey differences for waterfowl and shorebirds.
10. Provide more information about the effects of disturbance on waterfowl and shorebirds to develop suitable habitat buffer zones.
11. Determine the effects of channelization, levee alteration, and use of dredged-spoil on mobilization of contaminants sequestered in soils or sediments and bioaccumulation in waterfowl and shorebirds.
12. Characterize hydrology, biology, and chemistry of salt ponds heavily- and lightly-used by waterfowl and shorebirds to examine the differences.
13. Determine habitat values and use by waterfowl and shorebirds of managed wetlands versus tidal wetlands.
14. Investigate the effect non-native invertebrates and plants (e.g. *Potamocorbula amurensis*, *Spartina alterniflora*) on waterfowl and shorebirds.
15. Evaluate methods to reduce effects of non-native predators on waterfowl and shorebirds.
16. Examine the effects of contaminants on breeding birds.
17. Pilot Projects - encourage monitored experiments in wetland restoration or mitigation. Pilot Projects should:

a. Include repeatable waterbird surveys before and after project actions.
b. Examine maintenance or creation of salt pond systems, including low to mid-salinity ponds in the absence of commercial production. Habitat values and use should be maximized while minimizing maintenance costs.
c. Test methods of constructing habitat elements with low maintenance requirements such as bare roosting islands, intertidal pans, and non-tidal seasonal ponds.
d. Examine differences in use of different wetland unit sizes.
e. Test methods of increasing shorebird and waterfowl use of managed marshes.
f. Increase monitoring efforts on existing projects with habitat elements valuable for waterfowl and shorebirds.
g. Employ adaptive management by applying earlier findings to change design elements through time.
h. Conduct preliminary sampling for contaminants of areas designated for salt marsh restoration.
i. Conduct preliminary sampling of salt ponds for invertebrate community, salinity, and other water quality characteristics.

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